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LEAD COVERED CABLES.

OF the many forms of underground cables used for telephonic or electric light purposes the lead-covered type has received a great deal of support, and large quantities have been manufactured, especially in the United States. Various modifications in the insulating material employed have been adopted, but for the outside covering the lead casing may be taken as a distinct type when compared with other forms of protected cables. As regards the durability of this class of cable as at present manufactured the experience in this country may be said to be very limited, as the use of such lead-covered cables is of very recent date. In the United States, however, cables of this type have been used for telephonic purposes for some few years, and, consequently, some experience has been gained on the point of durability, to which we shall refer later on.

But, whilst electrical engineers and others who have the control of specifying the nature of the material and form of the cables to be adopted for certain works appear to have formed satisfactory opinions relative to certain types of cables from but evidently slight information, it would seem that no pains nor trouble have been taken to enquire into the early and past history of the type of cable decided upon.

In selecting lead-covered cables, we have a very notable instance, where the early history of this type appears to have been so totally neglected that one is almost led to believe that it has been considered of so novel a character as to be without any history at all. If any telegraph engineer, whose experience goes back to the old days when and before gutta-percha was introduced, were asked his opinion as to lead-covered cables, probably great surprise would be felt when it was mentioned that in those early days there had been gained a very considerable experience of the durability of this type of cable. And yet, in discussing it, no mention whatever has been made of the lead-covered cables manufactured and laid underground in the early days of telegraphy. It would seem that their duration was so short-lived—they left so little history—that, practically, it is beginning a new life, as if it were a new creation.

In all probability the principal element which is considered to be so greatly in favour of the durability of lead as a covering for a cable, is the unquestionable fact that *lead* in various forms, as gutters, water conduits, &c., has been found to be in a splendid state of preservation, after being in use for hundreds of years. This is an undoubted fact, and in many places leaden pipes are in use at the present day for carrying water from a distance, which were manufactured and laid down for that specific purpose some hundreds of years ago. But because a leaden pipe manufactured some hundred years ago is in use at the present time, are we to assume that a leaden pipe manufactured *at* the present time will be equally durable? To anticipate such a grand result, we should be certain that the pipes now manufactured are made of precisely the same material as those of our ancestors, and of the durability of which we have ocular proof. This might be considered by some as a trifling matter; it might be said that as the modern system of manufacture comprises pipes made from *pure* lead, the durability of the same should be unquestionable. But it is here, we think, the mistake comes in. The durable pipes of the ancients will be found, on examination and analysis, to have been manufactured with impure lead, or rather lead with an alloy—a natural alloy—which gave the material its durability. We, on the other hand, with our superior skill and knowledge, carefully extract those alloys, which, in a commercial sense, are more valuable than the lead, and make the "pure" metal into an article which is distinctly proved to be of questionable durability.

Leaving the so-called "lead" pipes of the ancients, it is interesting to come down to the more modern experience of the early telegraphists before we touch upon the more recent experience of the present day. We find that the earliest experience of underground wires belonging to the old Electric Telegraph Company (about 1846) was in connection with their London street work, the wires running from the old office in the Strand being carried in iron pipes, and thus constructed: "The conducting wire was wrapped with cotton thread, and then coated with a mixture of tar, resin, and grease, which was found to make a perfect insulation (perfect at that time). Nine wires so prepared were packed in a half-inch *leaden pipe*, and four or five such pipes were packed in an iron pipe about 3 inches in diameter." The introduction of gutta-percha insulated wires, however, shortly after led to these cables being removed, and the system then first tried, of drawing into iron pipes gutta-percha insulated wires, has been practically maintained to the present time. Gutta-percha covered wire was also shortly after this period used in leaden pipes; and it may be in the recollection of some that that which was originally intended for the shore ends of the first submarine cable between Dover and Calais in 1850 (a naked gutta-percha covered wire) was an insulated wire in a leaden pipe. We have no doubt that many of our readers have seen samples of this—the earliest specimen of submarine telegraphy. To show how this question of underground telegraphy and the use of leaden pipes as a protector must have entered into the consideration of those interested in the subject, we give the following abstract of a specification issued as early as the year 1845, which reads almost as if it had been issued but lately:—

No. 10,799, August 4th, 1845, William Young and Archibald McNair; an "improved method of manufacturing electric conductors," by covering metallic wires

with plaited cotton threads, and introducing them into a leaden pipe filled with pitch.

Two machines are described and shown for introducing the cotton-covered wires into a lead pipe filled with pitch. The top plate of an hydraulic press has a cylindrical chamber for hot lead; the action of the press squeezes the lead round the wires, they having already passed through a cistern of fluid pitch connected with the piston of the press, and moving with it. The wires (in a state of tension) are drawn through the cistern and a "hollow rod," to a "tubular core," and "die" moving in the lead chamber, which regulates the supply and shape of the pitch and lead supplied to the wire. The first machine has the lead cylinder between the hydraulic press and the tank, the tank being supported by the piston of the press; but the second machine has the hydraulic press between the tank and the lead cylinder, the tank being fixed to the press cylinder, but adjustable on it.

As regards laying the lead-covered cable we find the specification mentions: "If the electric conductors are to be used in great lengths on land, we propose carrying them in reels in a wheeled carriage, and while the pipe is being laid down one end is to be held fast as the carriage proceeds in the direction in which the pipe is to be laid, so that the reel may revolve upon the journals or centre, and thereby allow the pipe containing the wires to be unwound and delivered on the ground without risk of injury and with great facility." This shows that the patentees had thought the matter well over. As an item in the early history of telegraphy it is interesting to note the following paragraph which occurs in this specification:—"We also propose to use the leaden or other aforesaid metallic pipes or tubes as means of returning the electric currents conveyed by the metallic wires enclosed in such pipes." This was in 1845. The next step appears to have followed the adoption of gutta-percha covered wire, and as it was impossible to adopt anything like the preceding plan on account of the heat interfering with the gutta-percha, Mr. John Chatterton patented machinery in 1851 (see specification 13,660) for drawing the lead pipe over an insulated core and then passing it between rollers—a plan which remains in use at the present time. The little success attending the use of lead-covered cables, and their practical abandonment, leaves nothing to be noticed until the telephonic industry comes into play and lead-covered cables again come into use. In 1879 the Berthoud-Borel system was patented, and subsequently we have various other plans adopted, which are equally well known.

But as regards the experience of a practical character to be obtained from the use of lead-covered cables in recent years, we have in American official reports some very useful and reliable information which it is interesting to note, as the results bear very distinctly upon the durability of lead-covered cables. The Subway Commission of Brooklyn, reporting in April, 1886, remark on a conduit of creosoted wood previously reported on:—"This conduit has since been opened and examined, and is still in service, thus giving an aggregate test of 16 months' trial. Nothing was discovered by the examination above-mentioned which was unfavourable to the creosoted wood as material for the conduit. But it was found that in some places the lead of the casing of the cables had been seriously corroded (carbonated) by carbonic acid, probably contained in the "water gas"—illuminating gas—which had leaked into the pipe. This corrosion would have, apparently, destroyed the lead casing at the points where the action was most destructive, in about eighteen months. It was found, however, that only pure lead showed this reaction. Cables in the same conduit, the lead casing of which contained a little tin, were entirely unaffected. This discovery may lead to the exclusive employment of such an alloy for the casing of the cables hereafter, and it is believed that the ordinary lead pipe can be cheaply coated and thus sufficiently protected."

In September of the same year Mr. W. D. Sargent read a paper on the "Underground work in Brooklyn" before the National Telephone Association at St. Louis, in which some interesting and important information is given relative to the conduits and to the lead cables which were principally used:—"The durability of lead pipe is a very important question. The corrosion of the Brooks pipe has now reached one-eighth of an inch in depth, and the indications are that the whole pipe will be consumed. The pipe is said to be pure lead. The Western electric cables have a small percentage of tin, which was put in to stiffen the pipe; but it seems to serve another useful purpose, inasmuch as these cables, laid alonside the Brooks, show no signs of corrosion. It is fortunate that a remedy is so immediately indicated for what promises to be a serious evil."

In the following year, September, 1887, Mr. Sargent again read a paper on the Brooklyn underground work, and remarks:—"The Brooks cables, covered with pure, lead, have now been in service three years. The corrosion of the lead pipe noted last year is still going on, with indications that it will take several years more to reach the insulated wires. The Western electric cables, lead with a small percentage of tin, placed in the same conduit at the same time, show only a thin, hard white scale, with no indications that it is increasing. I think we may assume that a composition of lead and tin resists the action of the gases in the underground conduits."

In the present year, in September last, Mr. Sargent again contributes a paper on the same subject; and with reference to lead-covered cables, he says: "We are using nothing but the lead-covered type of cable, some of which has been in service underground for four years, and still in good condition. Of the cables which were laid four years ago those covered with pure lead appear to be more than half eaten through. Of the cables furnished by the Western Electric Company at the same time, in which there is a small percentage of tin mixed with the lead, the corrosion is very slight, and we are led to believe that cables covered with this alloy will last from three to four times as long as those covered with pure lead." "The durability of lead pipe, with a slight admixture of tin, the maintenance of a uniform and high insulation, together with uniform resistance of conductors after four years of service, are indications of length of life that are very encouraging."

Now here are experiencies which undoubtedly ought to prove valuable. The admixture of tin with the lead is essentially important; but instead of being termed a new discovery, it is simply assimilating the lead used to that material formerly employed by the "ancients," and of which we have the proof of permanent durability. The lead pipes, gutters, &c., to which we have previously alluded as being manufactured by the ancients, and by our ancestors, were made from the ore as obtained direct from the mines. Now lead, when obtained in the ore, is invariably found mixed in uncertain proportions with either tin or silver, or with both, and in that state or "alloyed" condition was melted and moulded or worked by our ancestors into the form required, whether short lengths of pipes or other requisites. The pipes we see nowadays, which have a history of several hundred years, are not made of pure lead, but of an alloy naturally formed, and it is to those alloys that the great durability of the old lead pipes is due. The result of the experience gained in Brooklyn is decidedly against the use of "pure" lead, that is, lead deprived of its natural alloys, and in favour of the admixture of tin either as an alloy or as a coating only. The proper proportions are matter of further experiment, but an analysis of some of the ancient leaden conduits will, in all probability, solve this problem.

There is another and important question involved in the use of lead piping or casing, and one which we think has a material bearing upon the question of decay and corrosion. It is the handling of the lead-covered cable after its completion. So far as we are aware, this is a matter which has hardly ever been considered in the light of a source of injury. When a lead cable is coiled on a drum the outer diameter of the lead tube becomes elongated, and the inner or lower surface becomes compressed. When

the cable is unwound the opposite takes place, the portion which was compressed is now elongated and the elongated part is compressed. This is an action which takes place throughout the length of the cable, and therefore each portion of the material is subjected to this double action. Now, lead is not an elastic metal, and cannot, like a steel rod or wire, be bent easily backward and forward, returning to its original form. The lead must give, must alter to some extent, and its surface becomes more or less altered and opened, and entirely different from its original smooth condition. An examination with care will soon show this. Take a roll of dough, to which lead may not inaptly be compared, and notice the result of bending it in a similar way. This deleterious action upon the mechanical form of the lead pipe can be more readily noticed if the coiling and uncoiling be repeated several times. To the opening out of the metal by this action there is every reason to suppose that there is given greater facility for chemical action on the outside. The admixture of an alloy of tin or silver at once alters the nature of the metal. Whilst giving it hardness, it also gives it elasticity, which makes it bear the strain of bending without undue harm following. From the additional hardness obtained and the requisite elasticity to resist coiling strains, the lead alloy is rendered comparatively free from chemical action and becomes a durable material. It may be mentioned that the pipes used by our ancestors were never coiled ; they were invariably used in very short, straight lengths, and only bent *in situ* when required.

Our object in drawing attention to the past and present experiences of this class of material as a covering for insulated cables, has been to show that such a material can be used with success and without it, and the results given should bring a profitable lesson. There are many cases in which the form of lead-protected cables has been found to answer remarkably well ; but the surrounding circumstances must have been specially favourable. But in the future use of this class of protection some care ought to be exercised in suiting the material to the surroundings, and to obtain all information possible from past experience. It may not be amiss to remark that in the case of a submarine telegraph engineer being requested to specify a cable for laying between definite points, he would at once not only make himself thoroughly acquainted with the nature of the depths, &c., between those points, but he would also give the various geographical considerations the attention requisite, and he would also investigate very carefully the experience of past submarine cables under similar circumstances, before deciding upon the form to be adopted. It should be so in the carrying out of any new work where the electric light industry is concerned, for it seems very inconsistent that in one place a lead covered cable should be laid in the ground without any protection at all, whilst at the same time in another place especial care is taken to protect the lead cable before it is laid down. We ourselves do not object to the use of lead for the protection of cables ; but we do object to its adoption and use without due regard to experience and full knowledge of what treatment it is likely to receive in the future. Our experience of the past has shown most distinctly the advisability of a careful consideration of the surrounding circumstances, and that whilst a distinct type of cable may answer in one place, it will fail in another. It might be well to point out that in electric lighting, as in telegraphy, there are to be met the same points of insulation, conduction, and construction ; these have been thoroughly investigated and threshed out in our long telegraphic experience ; that being so, this data ought to be considered, instead of starting new history which would only bring us back to the same points.

WE think that the paper by Mr. John W. Hill, which we conclude in this issue, should be carefully read by all who are interested in the cost of electric lighting. There are several points which seem to be at variance with practice on this side of the water, but it must be remembered that it is an Edison plant which is being dealt with, and we are under the impression that this is generally considered one of the least economical of systems. Much useful information is advanced respecting the cost of operating incandescent lamps for a given candle-power when new and when age has had a deteriorating effect upon them, and the results obtained from the meters, based upon the principle of electro-deposition, are highly interesting. It appears to us that the electrical constants were measured with more or less indifferent apparatus, and that while they might easily have been made with the greatest degree of accuracy they are not so reliable as the mechanical data. Nevertheless, there is much in the paper worthy of very close attention.

DR. VAN DER WEYDE not long since made himself somewhat ridiculous by displaying a painful want of knowledge of the principle of the Cardew voltmeter which was used during Mr. Harold Brown's famous dog-killing experiments. He does not shine any more brilliantly in the discussion which took place upon the Geyer-Bristol meter, which may be found in our other pages. "Currents of a very small number of ampères," says the worthy doctor, "have no heating effect ; it is the ampères which cause the heat, the electromotive quality does not." This puts us in mind of the celebrated dictum that "it aint the 'untin as 'urts the 'osses, its the 'ammer, 'ammer, 'ammer on the 'ard 'igh road." Prof. Geyer administered a mild correction to the irrepressible veteran, but even this, we fear, will not avail him much.

MR. EASSON, of the Wolverhampton Gas Company, is "animated with a sincere desire to keep the electric light in the background." Does not this savour somewhat of kicking against the pricks ? The remark was called forth by a "round robin" application by the workmen for more wages, an application which was acceded to in the hope that the men would become equally animated with the same sincere desire.

WHY is it that so many of our best electrical men never put in an appearance at the meetings of the Society of Telegraph-Engineers ? Surely there must a "something somewhere" to cause this systematic abstention from joining in interesting debates on current questions in electrical science on the part of men who are looked up to as authorities, and many of whom are lucid speakers, and—concise. If on an ordinary meeting night anyone looks round the theatre at No. 25, Great George Street, one sees anxious and eager students on all sides. We are only too glad to welcome them, but should be better satisfied that the society is really worthy of the proposed change of title to "Institute" if we could see a larger sprinkling of *sound* men at the meetings. Is the fault with the council or the mode of electing it, or is it apathy ? We sincerely trust that at the next meeting, when Mr. Preece's motion will be again discussed, the whole question will be thoroughly considered. The proceedings ought to be more dignified, more technical, more scientific, and anyone venturing to advertise merely his own wares ought to be made to feel that it were better he had never been born. We should then have a society in which questions of applied science would be impartially discussed.

THE importance of direct telegraphic communication between telegraph stations and coastguard, lifeboat, and life saving stations and lighthouses, has too often been insisted upon and generally recognised to require further argument; but still no attempt has been made to establish such a system. Sir George Baden Powell, however, intends to introduce a Bill next Session for this purpose, and he is said to have already sketched out a complete and practical system. For saving life at sea, for coast defence purposes, and for the general welfare of the shipping and fishing industries, such a system is imperative. As an illustration of the defects and serious results of the present very limited means of communication with lighthouses, it is useful to note that in connection with the Flamborough lighthouse, although the keepers can, in the daytime, communicate by telegraph with the village where the life-saving apparatus is kept, two miles away from the Head, that can not be done after the post office closes in the evening. After that time the coastguard men must send a messenger, and while he is covering the two miles, and the apparatus is being brought down, ships may easily go to pieces, and their crews be drowned. Rapid means of summoning the apparatus is more necessary at night than in the daytime; yet it is just during the dark hours that the telegraph is closed. The Americans are ahead of us in this matter—as, indeed, they are in regard to many other applications of electricity.

SURELY Mr. A. A. Campbell Swinton cannot be in earnest when he gravely suggests that the United Telephone Company should attach to all their instruments a fusible wire, for protection against accidental crossing with electric light conductors. We know the U. T. Company is not loved; we have even heard people remark, with a kind of fiendish joy, that the accident to which we referred last week "served them right," but really it is adding insult to injury when the company is gravely assured that it might be well if Mr. Campbell Swinton's advice be at once put into practice. Why should the United Telephone Company be forced to spend trifling sums, as they are lightly termed, upon all the apparatus of some 5,000 subscribers, just because an electric light contractor does not take the precaution to steer clear of the telephonic network. Surely those following others who have been for years in the field should be held responsible for mishaps of this kind, which cannot by any force of reasoning be considered as due to want of precaution on the part of telephone men.

SOME further experiments have recently been made in Mr. Edison's laboratory by Mr. Harold P. Brown, with the object of showing that the fears of those who doubted whether the electric current could be so applied as to cause instant death, whatever the weight of the living being operated on, are groundless. The first victim was a calf, weighing 124½ pounds. The hair was cut on the forehead, and on the spine behind the forelegs; and sponge-covered plates, moistened with a solution of sulphate of zinc, were fastened in place. The resistance of the animal was 3,200 ohms. An alternating current of 700 volts was applied for 30 seconds. The animal, however, was killed instantly. It was at once dissected by Drs. Ingram and Bleyer, but the brain, heart, and lungs were found to be in a normal condition, and the meat was pronounced fit for food. One metal plate carrying the current touched the hair of the forehead, and slightly burned it, but otherwise there were no external indications of injury. A second calf weighed 145 pounds, and had a resistance of 1,300 ohms. The alternating current at 700 volts pressure was applied for 5 seconds, and produced instant death. To settle permanently the weight question, a horse weighing 1,230 pounds was next killed by passing the alternating current at 700 volts from one foreleg to the other. The resistance of this animal was 11,000 ohms. Even these experiments do not seem to us to be convincing. We believe we are correct in assuming that, generally speaking, animals would fall victims to shocks which would not necessarily kill a human being.

WE read that the outer tube of Mr. Ferranti's 10,000-volt main will be at the potential of the earth, so that although it may be transmitting energy at the rate of 5,000 horse-power, the tube may be touched with impunity. This may be all very well so long as it remains at the earth's potential, but we know that it is not improbable that it may get out of this happy and safe condition. How, then?

WE believe that the majority of the members of the Society of Telegraph Engineers and Electricians, or, as we must now call it, the Institution of Electrical Engineers, are in favour of the voting for the council being placed on a different basis. It is evident that the list of eligible candidates should be made very much larger than has hitherto been the case, and even then members ought to have the privilege of substituting those of their own choice. This is a subject which would well bear discussion.

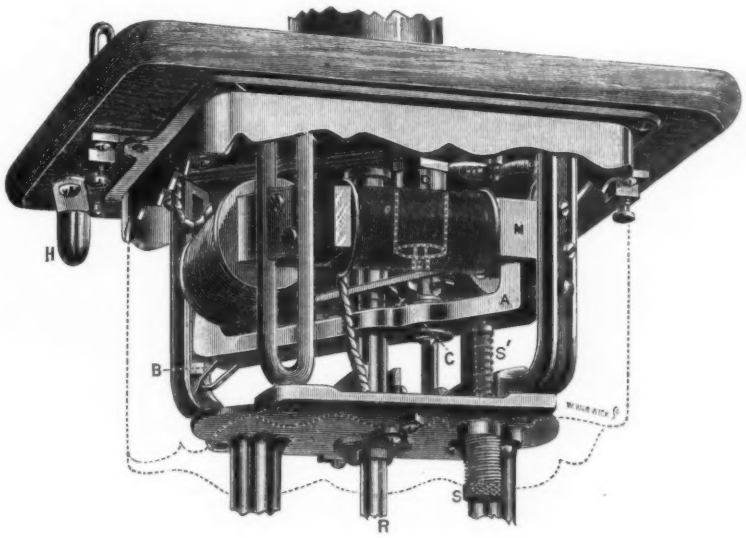
THE projectors of tramcar propulsion by electricity should certainly take heart of grace at the proposition which Mr. Reckenzaun is prepared to abide by. He is willing to supply his accumulators to any company desirous of purchasing and afterwards maintain them at the low price of a penny per car mile, provided a sufficient number of cars are placed on the road, which number he limits to four as a minimum.

WE believe that, owing to some legal difficulty, the contract for the Southwark Subway has not yet been definitely settled, although it is said that it has been promised to Messrs. Siemens Bros., who, we understand, undertake to indemnify the company working the subway against any action for infringement of patents. It is possible that we may enter into this matter more fully in another issue.

IT seems that quite a little stir is likely to be made in the Thames during the forthcoming year with electrically propelled launches. More than one constructor is in the field, and a little healthy competition will certainly reduce the prices for these elegant and really pleasure-giving boats.

THE WATERHOUSE ARC LAMP.

THE Waterhouse arc lamp, as illustrated below and described by the New York *Electrical Engineer*, has a magnet quadrangular in shape. Two independent conductors are wound upon it, the main being at right angles to the shunt. This produces two poles of constant polarity and two of variable polarity upon the magnet, and the variable poles are utilised in a manner subsequently described. Under the magnet, and diagonally across it, is pivoted an armature, A, on one end of which is a tongue that protrudes into the elongated hole in magnet, M. On the opposite end of armature, A, and above supports, B, the armature is rounded and pivoted to the magnet, M. When no current is passing through the lamps the pivot holds the armature in place while it rests upon supports, B. The tongue end of the armature, A, is supported by S'. Attached to the armature is clutch, C, which binds upon the carbon rod, R. The spring, S', assists the armature to form the proper arc, and its tension is regulated by the screw, S. Any sudden upward movement of the armature is opposed by the dash-pot, D,



and any sudden downward movement by the spring, S'.

The current entering the lamp at the terminal near handle, H, passes around the main coils, thence to the carbon rod and carbons, returning to the opposite terminal on the lamp board. This produces magnetism in magnet, M. The armature, A, is drawn up, acting upon the clutch which lifts the carbon rod, and the arc is formed. On the burning away of the carbons the excess of resistance is greater in the main than in the shunt coils, and a portion of the current is diverted through the shunt, this neutralises the magnetism in the variable poles of the magnet, as the shunt pole is an opposite one to the main. The neutralising of the magnetism allows the armature, A, to recede slightly by gravitation, easing up on the clutch and releasing the carbon rod which feeds the lamp. There is no sudden drop of the carbons, however, because the armature, A, is free from all mechanical friction and directly susceptible to the changes in the magnetism in magnet, M. A fine steady feed will therefore be maintained.

An automatic cut-out (not shown in the illustration) is placed on the other side of the magnet, and will cut the lamp out on a quarter of an inch separation of the carbons.

The Waterhouse lamp is thoroughly insulated, is said to be easy of adjustment, and is made with clutch feed, as shown, or with rack and pinion feed.

THE BOARD OF TRADE AND THE ELECTRIC LIGHT IN KENSINGTON.

IMPORTANT DECISION.

THE agitation and controversy which we have previously described as existing in Kensington respecting the introduction of the electric light, have brought forth an important decision from the President of the Board of Trade. The Chelsea Electricity Supply Company having applied to the special committee of the Kensington Vestry for leave to lay down connecting (not distributing) wires along a route already covered by another company's Provisional Order application, the committee wrote to the Board of Trade asking whether that department had or had not decided not to grant any further licences under the Act for the supply of electricity in London "where the areas are covered by pending applications for Provisional Orders." Apparently the London Supply Company had already made a similar enquiry, for in reply, the committee received a copy of a letter to that company, in which the following statements were made:—"After a careful consideration of the application, the Board of Trade are of opinion that there are grave objections to the granting of a licence for so large an area of the Metropolis, one of the most prominent of these objections being that no opportunity is afforded to Parliament to review the decision of the Board of Trade. In a matter affecting so many interests and such a large portion of the population of London, it is not, in the view of the Board of Trade, expedient that this action should be entirely without Parliamentary sanction, such as is given when the procedure is by Provisional Order. In these circumstances, the Board of Trade have come to the conclusion that they cannot properly proceed with the application referred to."

At the time of our last article on this subject (on December 7th) the report of the Electric Light Committee of the Kensington Vestry had been a second time referred back for further consideration and amendment. At the following meeting of the vestry, the committee, after reporting the above correspondence, stated that a deputation, comprising Mr. A. Staveley Hill, Q.C., M.P., Sir Theodore Hope, and Mr. Charles Fish, had waited upon the committee to urge that permission should be given to the Kensington Court Electric Lighting Company to extend their mains for the supply of the houses in the neighbourhood of Queen's Gate, Gloucester Road, and Cromwell Road. In support of their request, they said that many of the householders in that area had had their houses wired for the

electric light, and that not only were they suffering inconvenience through not receiving the supply, but special decorations which they had introduced were being injured by the other method of lighting (presumably gas) which they had been obliged to adopt. Letters to the same effect had been received from Sir F. Bramwell, Lord Chetwynd, and others. The committee, having regard to the Act of 1882, advised that if the company proposed to make an application for this purpose to the Board of Trade, the vestry should give their consent (believing that the interests of the parish would not be prejudiced), on condition that in the event of any general system being hereafter adopted by the vestry, the company undertook to change the mains now proposed to be laid in such manner as to conform to and generally be subject to such future system, and to lay down these mains in such a way as was approved by the vestry's surveyor. In connection with this recommendation, the committee quoted section I of the Act of 1888, which provides that "the grant of authority to any undertakers to supply electricity within any area, whether granted by licence or by means of a Provisional Order, shall not in any way hinder or restrict the granting of a licence or Provisional Order to the local authority, or to any other company or person within the same area." On this, the revised report, being considered by the full vestry, certain members sought to have it once more referred back, objecting to the last-mentioned recommendation as a "job" for the benefit of the "best bit" in the parish. Other members, however, who, on previous occasions had been somewhat severe upon the committee, now warmly supported the report, and in the end it was received and adopted. Thus some satisfactory progress has been made towards the solution of this complicated problem of lighting Kensington.

THE SPANISH SUBMARINE TORPEDO BOAT "PERAL."

SOME further details have reached us, respecting the submarine torpedo boat designed by Don Isaac Peral, but the Spanish journals we have had access to, and from which we obtained the scanty information we have reproduced, while dealing exhaustively with the merits of Senor Peral, and with the glory and honour which will accrue to Spain should the experiment prove a success, pay but little attention to the far more important side of the question—the mechanical and electrical particulars. For instance, we are told that the motive-power proceeds from 600 accumulators, but no mention is made of their size, weight or type. The horse-power evolved by the dynamos is given, but we are not informed as to their construction. We are told that the reflectors illuminate, when the boat is submerged, to a distance of 150 metres, and that the indicator for registering the depth as the boat sinks is most ingenious. Just enough to whet our curiosity.

Among the many details of construction which are stated to be the invention of Senor Peral, is the contrivance for accurately determining the direction in which a torpedo should be launched when the boat is submerged on approaching an enemy. A tube is protruded from the conning tower to a short distance above the surface. The upper end of this tube carries reflectors having a range of 4 miles, and which are arranged so as to reflect all objects within the radius on to a table placed directly under the lower extremity of the tube.

It is stated that the "Peral" is entirely different in design and construction from all preceding submarine boats. Mention is made of Monturiol's, built in Spain and tried at Barcelona and Alicante in 1859; the "Plongeur," invented by Brun, built in France in 1862; the "Nordenfeldt," constructed in 1884; the "Peacemaker," of Tuck, built on the Hudson; the "Nautilus," of Campbell, tried on the Thames; Waddington's submarine torpedo boat, tried at Liverpool; and the "Gymnote," which failed during the experiments recently carried out at Toulon.

The "Peral" has, up to the present, only been tried in dock, but it is stated that the mechanism which governs the descent and ascent of the boat works perfectly, as also does the apparatus for maintaining the boat in the desired position.

It is stated that Nordenfeldt offered Senor Peral a very large sum for his invention, an offer which was refused. We are further informed that the Spanish Government limited the expenditure on the boat to £8,000, an amount insufficient, it is said, for the inventor to fully develop his ideas, or to go beyond the building of a merely experimental boat.

THE TELEPHONE IN SWEDEN.

IT may be doubted whether in any other country in the world the telephone has made such progress as in Sweden. Thus a Swedish technical journal publishes statistics up to 1886 showing that the City of Stockholm, in proportion to the number of inhabitants, takes precedence in respect of the number of telephones in use over 12 European capitals and three great cities in the United States, as the following figures purport to show :—

	Number of inhabitants.	Number of apparatus.	Per 10,000 individuals.
Stockholm	215,000	4,978	232
Berlin	1,280,000	4,248	33
London	4,765,000	4,193	9
Paris	2,800,000	4,054	14
Rome	300,000	2,054	68
Copenhagen ...	274,000	1,336	49
Amsterdam... ...	335,000	1,195	36
St. Petersburg ...	850,000	1,100	13
Vienna	1,200,000	946	8
Brussels	380,000	803	21
Helsingfors ...	46,000	575	125
Madrid	478,000	270	6
New York	1,500,000	3,700	25
Chicago	600,000	3,500	58
Brooklyn	650,000	2,375	37

The journal adds that since then the number of telephone apparatus in Stockholm has greatly increased; but for some cities no statistics more recent are available.

Turning to official statistics just published it appears that at the beginning of this year the number of telephone cables in Sweden belonging to the State was 1,687, with a total length of 4,324 kilometres, and the number of apparatus 1,964, of which 82 were installed at telegraph and central telephone stations and 1,883 with subscribers. The number of central telephone stations was 33, and the number of telegraph stations with telephonic connection 66. The number of telegrams transmitted by the aid of the telephone and of the messages forwarded at the Government telegraph stations were as follows :—

Telephone and telegrams	41,569
Telephonic communication	6,483
„ conversations (at a cost of 6d. each)	18,045
„ „ by subscribers ...	2,962,779

With the private telephones, having a length of 27·471 kilometres, the result was as follows :—

Number of central stations	248
„ „ subscription stations	12,989
„ „ switch apparatus	356
„ „ telephonic apparatus	13,722

If to this be added the State telephones the figures for the whole of Sweden stands as follows :—

Length of cables	31,795 kms.
Number of central stations	281
„ „ subscription stations	14,872
„ „ switch apparatus	397
„ „ telephonic apparatus	15,645

During last year 1,300 kilometres of new cable were

laid by the State, and 386 new stations opened, whilst 140 kilometres were laid for connecting private cables with the State telegraphs. The cost of all telephonic improvements and extensions by the State in 1887 amounted to £6,000.

The General Telephone Company of Stockholm has decided upon raising its capital from £25,000 to £50,000.

From the report of the Bell Telephone Company—the second in Stockholm—for 1887, it appears that 98 new apparatus had been installed and 190 removed; the number of subscribers at the end of the year being 1,755. The number of employés was 73, and the net profit £1,500. The company has contracted a loan with the Bell Telephone Company, Limited, of London, for £7,500, repayable before 1892, the shareholders waving all claim to dividend until the amount is paid.

Questions of the greatest importance to those interested in the Stockholm telephones are now under consideration, the most important one being the proposed amalgamation of the two rival companies in that city, viz., the Allmänna, or General, and the Bell companies.

The companies having appointed delegates the Bell representatives proposed that all the wires of both companies should be connected and business henceforth be carried on as if one concern. However, such a solution of the question the General representatives could not agree to, on account of the enormous advantages which the Bell subscribers would derive from such an arrangement, the former company having double the number of subscribers. Instead, the General proposed that a tax of 20 öre (3d.) shall be paid for every communication between subscribers of the two companies. This proposal the Bell Company was, however, unable to accept, and thus the question remains at present, but there can be no doubt that negotiations will soon be resumed which will lead to an amalgamation of the two companies. It may, therefore, be of interest to add that at present the General Company have 2,969 subscribers of its own and 822 joint subscribers with the Bell Company, the latter having 1,449 and 627 respectively.

Another proposal was made by the State Telegraph Board to purchase the plant and business of the Bell Company, but this proposal had to be rejected, the chairman of the General Company, who holds most of the shares in the former company, opposing the transfer.

The Swedish Government will present a bill to the next Diet, proposing the amalgamation of the telegraph and post services.

In the last diet the Government proposed to tax every private telephonic apparatus connected with a central station with a sum of 10 kr. (11s.) per annum, whilst no tax was to be paid by those using the State telephones, but the proposal was rejected by the joint voting of the two chambers, having been accepted in the lower and rejected in the upper chamber. The proposal was meant to bring up the revenue from the telegraphs to its former level this source of income having greatly decreased since the introduction of the telephone.

The General Telephone Company of Stockholm, referred to above, appears to display great activity even outside Stockholm, a proposal having been made to the Government to erect a telephone from Stockholm to Gothenburg, *viâ* Jönköping, whereby the capital on the Baltic, and the "Liverpool of Sweden," on the south-west coast, would be in direct communication, together with land lines to all the most important towns in the south of Sweden—a proposal amounting in reality to grant the company a monopoly for telephonic communication in the whole of that part of the country, although the Government was to have the option of buying up the lines at any time. It was proposed to erect double copper wires (the connections in existence now being single and the wires of iron), it having been found how excellently the double wire system works on the long distances between Paris and Brussels and Berlin and Hamburg. Another proposal was also made for erecting a telephone line from Stockholm, along the whole shores of the Baltic, to Hudiksvall, embracing all the great commercial towns along that sea border. However, on the recommendation of the Telegraph Board, the Government rejected both proposals, on the ground that telephonic connections of the kind proposed by the general company should be done exclusively by the State; that the company would practically monopolise the whole of the telephonic business in the south of Sweden; that the Crown possessed the sole patent for erecting the system of double wires in Sweden; and that, finally, the wires proposed by the company—2·5 mm.—were too thin for such distances.

Since then the board has proposed to erect the line Stockholm-Gothenburg as a State line, at a cost of £12,500, with double wires 3 mm. in thickness, the principal towns obtaining connection with the two important termini to contribute a share. This proposal will no doubt be agreed to.

In the country, too, in Sweden, the telephone is becoming more and more extensively used; for instance, the whole of central Sweden is now thus connected, whilst several new towns in other parts are introducing the invention. Even into the church the telephone has penetrated in Sweden, in all probability the first country in Europe where it has been adopted for such a use; the chapel of Imanuel, in the town of Nonköping, having been fitted with two transmitters on each side of the pulpit, whereby those subscribers who may be prevented from attending the service are enabled to hear the sermon in their homes.

The Telegraph Board made a proposal to buy up the Sundsvall Telephone Company for a sum of £4,500, and to lower the rate of subscription from £5 to £4 10s. per annum, but the proposal has been rejected. The Board has, however, succeeded in buying up the Gothenburg Bell Telephone Company, and the lines outside the boundary of that city, belonging to the General Telephone Company of Gothenburg. Shortly the Crown will, no doubt, also acquire the rest of the plant belonging to this company, an offer having been made by the latter to that effect. Another offer made by the company's active Stockholm prototype to take over the concern and thereby gain a footing in Gothenburg also, has been rejected.

Recently some experiments were made in long-distance telephoning between the towns of Falun and Gothenburg with an apparatus made by Messrs. Ericsson, the well-known Swedish electrical engineers, of Stockholm, on the principle of the American Dr. Rose's apparatus, which is said to be capable of conveying messages a distance of 1,500 miles, but in this case the experiments were unsuccessful, although the distance was only some 200 miles; perhaps through some inaccuracy in the drawings received from America.

It will therefore be seen that the Swedes, with their high culture, have not been slow in appreciating the advantages of this wonderful invention of our century.

Proposed Taxation of the Electric Light in New York.—A New York contemporary, under the heading "Looks Like a Grab," prints the following:—Emboldened by their success in other matters, the gentlemen from Pittsburg, Cincinnati, St. Louis, and other inland towns, who with the superintendents of railroads centreing in New York form the Board of Steam Navigation, have started a movement to do away with all electric lights along the harbour and rivers, including the torch of the Goddess of Liberty and the beautiful crescent of light that defines the Brooklyn Bridge at night. Captain Michael Moran complained that the lights on the bridge and the torch of the Goddess interfered very much at night with navigation, especially with his tug boats that tow out the mud scows. It is proposed to have a law passed imposing a fine of £40 for every electric light that is exposed unshaded in the harbour or rivers, and a committee has been appointed to have such a law enacted.

TEST OF AN EDISON INCANDESCENT ELECTRIC LIGHTING PLANT.*

By JOHN W. HILL, M. Am. Soc. C.E.

(*Concluded from page* 691.)

5. NOTES OF EXPLANATION OF THE TABLES OF DATA.

THE record of the lights in hourly service in and about the depôt building may for convenience be divided into (*a*) lights throughout the building, not including the train shed, omnibus court, Smith Street cross lights, or American Express building; (*b*) lights in the train shed, omnibus court, cross lights over the railroad tracks west of the station; (*c*) lights in the American Express building.

Lights (*a*) and (*b*) were taken by two sets of observers, day and night, during the eight days of trial. Lights (*c*) were taken for the nights of October 18th, 19th, and 20th, and averaged for the trial. Lights (*a*) were read hourly, and averaged for the day service, 6 a.m. to 5 p.m., and for the night service, 6 p.m. to 5 a.m., and for shorter day and night intervals, to correspond with the intervals during which the work of the engines and current generators were being measured. Lights (*b*) were read by rows from the switch-board in the train shed, for the intervals and total time of service for each night of the test. Lights (*c*) were read for intervals and total time of service each night, and also by hours, from 6 p.m. to 6 a.m.

Tables "A" to "E," inclusive, embrace the lamps in service during the entire trial, in detail as follows:—Table "A" contains the record of the day service of lamps in the depôt building, from 6 a.m. to 5 p.m., for each of the eight days of test; table "B" contains the record of the night service of lamps in the depôt building, 6 p.m. to 5 a.m., for each day of the eight days of test.

Referring to tables "A" and "B," columns 1 to 14, inclusive, are explained by the headings; column 15, table "A," contains the average hourly lamps for that portion of the day, 10 a.m. to 5 p.m., inclusive, during which the power of the driving engines was measured; and column 16 contains the average of lamps per hour for the entire day (12 hours). Column 15, table "B," contains the average of hourly lamps for that portion of the night, 6 p.m. to 10 p.m. inclusive, during which the power of the driving engines and work of the dynamos were measured, and column 16 contains the average lamps per hour for the entire night (12 hours).

Table "C" contains the lamps in service in the warerooms and stables of the American Express Company, for the dates noted; divided into sub-tables, "C" 1, containing the hourly record of lamps in service; "C" 2, containing the average hourly service between 5 p.m. and 7 a.m; and "C" 3, the average hourly service between 5 p.m. and 10 p.m., corresponding with the hours during which the work of engines and dynamos were measured.

* From the Transactions of the American Society of Civil Engineers, June, 1888.

TABLE "A."—HOURLY RECORD OF DAY LAMPS.

Date.	Lamps. Nominal C.P.	Time. A.M. 6	7	8	9	10	11	12	P.M. 1	2	3	4	5	Average part day.	Average part night.
October 11	16	85	71	94	71	70	80	64	81	90	91	92	126	...	84·58
	32	6	5	8	10	7	9	8	9	12	10	12	10	...	8·83
„ 12	16	92	73	89	85	83	82	72	69	82	85	87	116	...	84·58
	32	6	5	8	10	10	10	8	9	10	10	10	10	...	8 83
„ 13	16	91	75	72	73	70	70	66	62	74	78	83	106	81 20	76·66
	32	7	5	7	9	9	10	7	8	9	9	10	11	9·73	8·42
„ 14	16	100	68	86	99	86	86	70	61	76	85	85	118	86·06	85·00
	32	7	5	11	10	10	10	7	8	8	9	10	10	9·20	8 75
„ 15	16	90	79	83	76	83	79	64	67	80	84	87	111	85·51	81·92
	32	5	7	9	11	11	12	11	10	9	12	12	10	11·36	9·916
„ 16	16	87	66	61	39	29	28	28	30	29	29	31	34	29·86	40·92
	32	10	6	7	6	6	6	5	5	5	5	4	4	4 85	5 75
„ 17	16	113	76	86	92	78	77	66	63	72	81	87	113	79·85	83 666
	32	8	7	9	10	10	11	9	10	10	10	10	14	10·57	9·83
„ 18	16	97	72	80	82	75	82	74	71	84	88	93	142	...	86·666
	32	7	6	8	10	10	10	9	10	10	10	12	14	...	9·666

TABLE "B."—HOURLY RECORD OF NIGHT LAMPS.

(Exclusive of Train Shed and Express Office.)

Date.	Lamps. Nominal C.P.	Time. P.M. 6	7	8	9	10	11	12	A.M. 1	2	3	4	5	Average from 6 to 10.	Average whole night.
October 11 and 12 ...	16	248	231	226	182	138	125	78	76	76	76	74	77	...	133·91
	32	35	34	35	32	23	21	5	5	5	5	6	7	...	17·75
„ 12 „ 13 ...	16	276	256	255	247	214	162	82	78	79	77	78	81	...	157·08
	32	39	38	35	35	29	23	6	5	5	5	5	8	...	19·42
„ 13 „ 14 ...	16	278	231	229	212	182	129	91	77	75	75	73	77	226·4	144·08
	32	31	31	31	29	27	21	7	7	7	7	7	7	29·8	17·666
„ 14 „ 15 ...	16	252	225	230	209	181	135	84	81	77	77	78	80	219·4	142·41
	32	32	31	31	29	22	19	8	7	6	6	6	8	29·0	17·08
„ 15 „ 16 ...	16	261	226	222	213	184	149	88	82	79	77	76	80	221·2	144·75
	32	29	31	31	31	22	19	5	5	5	6	6	7	28·8	16·42
„ 16 „ 17 ...	16	210	220	216	199	176	120	82	81	77	77	77	80	204·2	154·58
	32	30	29	29	27	27	19	7	7	7	7	7	9	28·4	17·08
„ 17 „ 18 ...	16	277	226	228	217	179	134	86	81	78	77	76	78	225·4	144·75
	32	31	30	30	28	22	20	7	7	7	6	6	7	28·2	16·75
„ 18 „ 19 ...	16	266	229	157	218	187	142	88	82	79	78	78	81	...	140·4
	32	32	31	31	29	25	20	5	5	5	5	5	7	...	18·0

Tables "D" and "E" exhibit the lamp service for the eight days of test in the train shed. (This embraces the rows of lights over the railroad tracks, the lights in the lobby at the east end of the shed known as the gate row, the lights in the omnibus court at the easterly entrance of the depot, and the lights along the tracks west of the depot. These lamps are divided into twelve rows or series, and controlled from a single switch-board in the train shed). In recording the service the observer noted the rows and times of opening and closing the circuits on the switch-board; and the tables contain the total time for which each particular series of lamps were in use for each day of the test.

The form of sub-divisions of table "D" and "E" is alike for all. At the head is given the date for which such table is compiled. Column 1 contains the number on the switch-board of the series or row of lamps; column 2 contains the number of lamps in the row; column 3 contains the hours and minutes of service; column 4 contains the lamp hours, and is the product of the lamps in the series multiplied by the hours and decimal of service; column 5 contains the average lamps in service per hour estimated for the hours between which the respective series of lamps are first lighted and last extinguished. Series 1, 2, 3, 4, 5, 6, 8, 9, 11 and 12 are taken for six hours, series 7 for twelve hours, and series 10 for seven hours.

Table "F" exhibits the total average lamps for the night service, from 6 p.m. to 6 a.m., and brings together the lamps for the depot building, American Express Company building (which is furnished with light from the electric lighting plant) and train shed. The headings of the columns sufficiently explain their contents.

Table "G" exhibits the same data as Table "F," but for the interval of time embraced between the hours of 6 p.m. and 10 p.m.

Table "H" contains the average revolutions of the driving engines, arranged for the day and night service of the plant.

Table "J" exhibits a comparison of the speeds of engines and dynamos for same intervals of time, and shows the slip of belts, or loss of motion between the engine and dynamo pulleys. The contents of the columns will be understood from the respective headings. (Assuming no slip of belts, the revolution of the dynamo armature should be directly as the diameters of driving and inversely as the diameters of driven pulleys.) The pulleys were carefully measured for circumference with a Chesterman tape, and found to be of diameters as stated earlier in this paper. The speeds given in column 5 of this table are obtained by multiplying the known speeds of engines by 5·207 or 5·132 respectively, and the percentage of engine speed realised by dynamo, column 6 is had by multiplying the values in column 4 by 100, and dividing by the values given in column 5.

Table "K" exhibits the indicated horse-power of the driving engines, arranged for the day and night service of the plant.

Table "L" exhibits the performance of the boilers during certain intervals of the eight days of the trial, divided into two sub-tables, of observed and calculated data.

Table "M" exhibits the calorimeter work for test of the quality of steam furnished by the boilers, and contains the averages of thirty-four observations of weights of steam condensed, water heated by the steam, and initial and final temperatures of water heated; the coefficient of saturated steam, 0·9666 was used to reduce the apparent to the actual evaporation in Table "L."

Table "N" exhibits in parallel columns the indicated horse-power of the engines; average lamps in hourly service for the intervals during which the power of engines was measured; equivalent lamps of 16 nominal candle-power; and number of 16 nominal candle-power lamps per indicated horse-power of engines. The actual 16 and 32 candle-power lamps given in column 4 are taken from the hourly records shown in detail in Tables "A" to "E;" and the 32 candle-power lamps are reduced to the equivalent number of 16 candle-power lamps in the ratio of two to one, in accordance with the results given under head of "Illuminating Power of Lamps," wherein it appears that the electrical energy per actual candle-power of the specimen 16 and 32 nominal candle-power lamps tested for brilliancy and current are alike, or 3·377 and 3·363 watts respectively.

TABLE "C."

AMERICAN EXPRESS OFFICE AND STABLE LAMPS.

Record of Lamps by Hours.

Date.	Lamps. Nominal C.P.	P.M. 6	7	8	9	10	11	12	A.M. 1	2	3	4	5	6
Oct. 18	16	11	10	2	1	1	1	1	0	0	0	5	5	5
and 19	32	5	7	2	2	2	2	2	2	2	2	4	4	4
Oct. 19	16	10	10	5	1	1	1	0	0	0	0	4	5	2
and 20	32	6	7	2	2	2	2	2	2	2	2	3	3	3
Oct. 20	16	10	10	4	1	1	1	0	0	0	0	4	5	2
and 21	32	6	7	2	2	2	2	2	2	2	2	4	4	4

BETWEEN 5 P.M. AND 7 A.M.

October 18–19.	Average hourly	16	C.P. lamps	... 3·215
	" "	32	" "	... 3·291
October 19–20.	" "	16	" "	... 3·194
	" "	32	" "	... 2·263
October 20–21.	" "	16	" "	... 3·125
	" "	32	" "	... 3·402
Average for three nights		16	" "	... 3·178
" "		32	" "	... 2·985

BETWEEN 5 P.M. AND 10 P.M.

October 18.	Average hourly	16	C.P. lamps	... 4·73
	" "	32	" "	... 3·50
October 19.	" "	16	" "	... 5·46
	" "	32	" "	... 4 05
October 20.	" "	16	" "	... 5·28
	" "	32	" "	... 3·70
Average for three nights		16	" "	... 5·157
" "		32	" "	... 3·75

TABLE "D."—RECORD OF LAMPS. TRAIN SHED.

All 32 C.P. Lamps.

October 11th. No. of row.	Lamps.	Service. H. M.	Lamp hours.	Average lamps per hour.	October 12th. No. of row.	Lamps.	Service. H. M.	Lamp hours.	Average lamps per hour.
1	7	3 23	23·681	3·947	1	7	3 00	21·00	3·500
2	7	1 33	10·850	1·808	2	7	2 47	19·481	3·247
3	7	4 08	28·931	4·822	3	7	4 04	28·462	4·744
4	6	1 54	11·400	1·900	4	6	2 35	15·498	2·583
5	7	3 04	21·462	3·577	5	7	3 10	22·162	3·694
6	6	0 57	5·700	0·950	6	6	2 55	17·496	2·916
7	6	11 37	69·696	5·808	7	8	12 14	97·864	8·155
8	6	1 38	9·798	1·633	8	6	3 17	19·698	3·283
9	9	2 23	21·447	3·574	9	9	3 09	28·350	4·725
10	7	5 37	39·312	5·616	10	7	6 17	43·981	6·283
11	6	2 40	15·996	2·666	11	2	6 02	12·066	2·011
12	14	4 04	56·924	9·487	12	14	4 03	56·700	9·450

October 13th. No. of row.	Lamps.	Service. H. M.	Lamp hours.	Average lamps per hour.	October 14th. No. of row.	Lamps.	Service. H. M.	Lamp hours.	Average lamps per hour.
1	7	2 41	18·781	3·130	1	7	1 55	13·412	2·235
2	7	1 58	13·762	2·294	2	7	1 37	11·312	1·885
3	7	4 12	29·400	4 900	3	7	3 53	27·181	4·530
4	6	2 34	15·396	2·566	4	6	2 36	15·900	2·600
5	7	2 07	14·840	2·473	5	7	3 31	24·612	4·102
6	6	1 59	11·898	1·983	6	6	3 45	22·500	3·750
7	8	11 38	93·064	7·755	7	8	12 13	97·728	8 144
8	6	3 09	18·900	3·150	8	6	2 44	16·398	2·733
9	9	2 56	26·397	4·399	9	9	2 58	26·694	4·450
10	7	6 31	45·612	6·516	10	7	5 42	39·900	5·700
11	4	5 02	20·132	3·355	11	4	4 26	17·732	2·955
12	14	4 48	67·200	11·200	12	14	4 33	63·700	10·616

NOTE.—Row 7 averaged for 12 hours. Row 10 averaged for 7 hours. All others averaged for 6 hours.

TABLE "E."—RECORD OF LAMPS. TRAIN SHED.

All 32 C.P. Lamps.

October 16th.					October 16th.				
No. of row.	Lamps.	Service.	Lamp hours.	Average lamps per hour.	No. of row.	Lamps.	Service.	Lamp hours.	Average lamps per hour.
		H. M.					H. M.		
1	7	2 44	19·131	3·188	1	7	3 54	13·300	2 216
2	7	1 16	8·862	1·477	2	7	1 02	7·231	1·205
3	7	2 29	17·381	2·897	3	7	3 10	22·162	3 694
4	6	1 51	11·100	1·850	4	6	1 40	9·996	1·666
5	7	3 06	21·700	3·616	5	7	2 36	18·200	3·033
6	6	3 44	22·398	3·733	6	6	2 11	13·098	2·183
7	8	11 45	94·000	7·833	7	8	11 13	80·728	7·477
8	6	2 49	16·896	3·816	8	6	2 04	12·396	2·066
9	9	2 38	23·697	3·949	9	9	2 37	23·544	3·924
10	7	6 17	43·981	6·283	10	7	5 38	30·431	5·633
11	4	5 01	20·064	3·344	11	4	5 29	21·932	3·655
12	14	4 05	57·162	9·527	12	14	4 14	59·262	9·877

October 17th.					October 18th.				
No. of row.	Lamps.	Service.	Lamp hours.	Average lamps per hour.	No. of row.	Lamps.	Service.	Lamp hours.	Average lamps per hour.
		H. M.					H. M.		
1	7	2 10	15·162	2·527	1	7	2 35	18 081	3·013
2	7	1 13	8·512	1·419	2	7	1 46	12·362	2·060
3	7	3 28	24·262	4·044	3	7	3 46	26·362	4·394
4	6	1 51	11·100	1·850	4	6	3 17	19 698	3·283
5	7	3 13	22·512	3·752	5	7	3 49	26·712	4·452
6	6	3 05	18·498	3·083	6	6	3 48	23·800	3·800
7	8	11 45	94·000	7·833	7	8	11 45	94·000	7·833
8	6	1 39	9·900	1·650	8	6	3 44	22·398	3·733
9	9	2 46	24·894	4·149	9	9	3 05	27·747	4·624
10	7	6 06	42·700	6·100	10	7	6 04	42·462	6·066
11	4	5 45	23·000	3·833	11	4	6 00	24·000	4·000
12	14	4 30	63·000	10·500	12	14	4 57	69·300	11·550

TABLE "F."—TOTAL AVERAGE LAMPS NIGHT SERVICE— 6 P.M. TO 6 A.M.

Date.	Lamps Nominal C.P.	Building.	Express Office.	Train Shed.	Total.
October 11	16	133·91	3·178	...	137·088
,, ...	32	17·75	2·985	26·266	47·001
,, 12	16	157·08	3·178	...	160·258
,, ...	32	19·42	2·985	31·897	54·302
,, 13	16	144·08	3·178	...	147·258
,, ...	32	17·666	2·985	31·282	51·933
,, 14	16	142·41	3·178	...	145·588
,, ...	32	17·08	2·985	31·397	51·462
,, 15	16	144·75	3·178	...	147·928
,, ...	32	16·42	2·985	29·697	49·102
,, 16	16	134·58	3·178	...	137·758
,, ...	32	17·08	2·985	27·523	47·598
,, 17	16	144·75	3·178	...	147·928
,, ...	32	16·75	2·985	29·795	49·530
,, 18	16	140·40	3·178	...	143·578
,, ...	32	18·00	2·985	33·827	54·812

TABLE "G."—TOTAL AVERAGE LAMPS NIGHT SERVICE—6 P.M. TO 10 P.M.

Date.	Lamps Nominal C.P.	Building.	Express Office.	Train Shed.	Total.
October 11	16	205·00	5·157	...	210·157
,, ...	32	31·8	3·750	45·788	81·338
,, 12	16	249·6	5·157	...	254·757
,, ...	32	35·2	3·750	54·591	93·541
,, 13	16	226·4	5·157	...	231·557
,, ...	32	29·8	3·750	53·721	87·271
,, 14	16	219·4	5·157	...	224·557
,, ...	32	29·0	3·750	53·700	86·450
,, 15	16	221·2	5·157	...	226·357
,, ...	32	28·8	3·750	50·513	83·063
,, 16	16	204·2	5·157	...	209·357
,, ...	32	28·4	3·750	46·629	78·779
,, 17	16	225·4	5·157	...	230·557
,, ...	32	28·2	3·750	50·740	82·790
,, 18	16	211·4	5·157	...	216·557
,, ...	32	29·6	3·750	58·808	92·158

TABLE "H."

SPEED OF ENGINES—REVOLUTIONS PER MINUTE.

Date.	Time.	East Engine.	West Engine.
October 12	Day	...	233·92
,, 12	Night ...	225·96	230·00
,, 13	Day	229·60	...
,, 13	Night ...	Counter off	233·36
,, 14	Day	...	231·84
,, 14	Night ...	228·89	Counter off.
,, 15	Day	229·59	...
,, 15	Night ...	221·62	232·47
,, 16	Day	...	231·96
,, 16	Night ...	230·80	237·03
,, 17	Day	229·86	...
,, 17	Night ...	226·59	233·20
,, 18	Day	...	235·68
,, 18	Night ...	227·36	231·97

TABLE "J."

COMPARISON OF SPEED—ENGINES AND DYNAMOS.

Date.	Engine.	Revolutions per Min. Engine.	Revolutions per Min. Dynamo.	Theoretical Rev. per Min. of Dynamo.	Percentage of Engine Speed Realised.
Oct. 12.	West, a.m.	236·358	1,172·0	1,212·99	96·62
,, 13.	East, ,,	229·600	1,152·0	1,195·53	96·36
,, 13.	West, p.m.	233·360	1,158·57	1,197·60	96·74
,, 14.	,, ,,	231·840	1,159·33	1,189·80	97·44
,, 14.	East, p.m.	228·890	1,137·60	1,191·83	95·45
,, 15.	,, a.m.	230·000	1,145·43	1,197·61	95·64
,, 15.	West, p.m.	232·470	1,162·66	1,193·03	97·45
,, 15.	East, ,,	221·620	1,109·00	1,154·00	96·10
,, 16.	West, a.m.	231·600	1,156·00	1,188·57	97·26
,, 16.	,, ,,	230·250	1,138·66	1,181·64	96·36
,, 16.	East, p.m.	230·900	1,169·66	1,202·29	97·28
,, 17.	,, a.m.	230·460	1,145·33	1,200·00	95·44
,, 17.	West, p.m.	232·57	1,165·33	1,210·99	96·23
,, 17.	East, ,,	224·82	1,128·50	1,170·63	96·41

Average, East	96·097
,, West	96·870
Slip of belts, East engine	3·903
,, ,, ,, West ,, ...	3·130

NOTE.—Fly-wheel, West Engine, covered with paper.
,, East ,, not covered with paper.

TABLE "K."—INDICATED HORSE-POWER OF ENGINES.

Date.	Time.	East engine.	West engine.
		Horse-power.	Horse-power.
October 12	Day	.....	.....
,, 12	Night	.....	.....
,, 13	Day	21·327	.....
,, 13	Night	35·975	32·888
,, 14	Day	.....	22·027
,, 14	Night ... ,,	39·701	34·008
,, 15	Day	21·493	.....
,, 15	Night	35·863	38·076
,, 16	Day	.....	13·777
,, 16	Night	33·425	32·586
,, 17	Day	22·904	.....
,, 17	Night	36·377	34·624
,, 18	Day	.....	.....
,, 18	Night	.....	.....

TABLE "L."—PERFORMANCE OF BOILERS.—DATA.

Date.	Time starting.	Time stopped.	Hours water measured.	Tanks used.		Total water.	Total coke.
				No. 1.	No. 2.		
	A.M.	P.M.	Hrs. Min.			Pounds.	Pounds.
Oct. 11	9.25	7.17	9 52	10	10	17,502·50	2,535·00
,, 12	7.20	7.16	11 56	11	12	20,133·25	2,545·50
,, 13	7.00	5.25	10 25	8	7	13,121·50	1,974·14
,, 14	7.00	9.55	14 55	15	15	26,253·75	3,195·92
,, 15	7.00	5.00	10 00	7	7	12,251·75	1,593·93
,, 16	7.00	9.50	14 50	13	13	22,753·25	2,990·58
,, 17	8.15	5.55	9 40	8	7	13,121·50	1,973·64
	P.M.	A.M.					
,, 18	2.00	1.00	11 00	13	12	21,872·75	2,602·90

ECONOMY.—STEAM PER POUND OF COKE.

Date.	Apparent evaporation.	Actual evaporation.	Temp. feed water.	Evaporation from and at 212° Fahr.
October 11 ...	7·023	6·788	67·0	7·811
„ 12 ...	7·909	7·645	66·5	8·801
„ 13 ...	6·646	6·424	65·8	7·400
„ 14 ...	8·215	7·941	64·0	9·161
„ 15 ...	7·686	7·429	64·2	8·569
„ 16 ...	7·608	7·354	63·7	8·493
„ 17 ...	6·648	6·426	62·6	7·422
„ 18 ...	8·403	8·122	62·6	9·381
Average		7·266	.....	8·380

TABLE "M."—QUALITY OF STEAM.—CALORIMETER.

Average steam condensed, pounds	12·763
„ water heated „	200·00
„ initial temperature, Fahr.	62·42
„ „ „ corrected	62·43
„ final „ Fahr.	129·34
„ „ „ corrected	129·66
Range	67·23
Heat units per pound of steam	1,183·174
Average steam pressure, pounds	80·057
Heat units at observed pressure	1,212 720
Difference	29·546
Latent heat of steam	885·590
Percentage of water entrained	3·336
Efficiency of steam.	0·97564

TABLE "N."—COMPARISON OF POWER AND LAMPS.

Date.	Time.	Horse Power.	Lamps. 16 C.P.	Lamps. 32 C.P.	Equivalent 16 C.P. Lamps.	16 C.P. Lamps Per H.P.
Oct. 13	Day	21·327	81·20	9·73	100·66	4·719
„ 13	Night	68·863	231·557	87·271	406·099	5·897
„ 14	Day	22·027	86·06	9·29	104·64	4·750
„ 14	Night	73·709	224·557	86·450	397·457	5·392
„ 15	Day	21·493	85·51	11·36	108·23	5·035
„ 15	Night	73·939	226·357	83·063	392·483	5·308
„ 16	Day	13·777	29·86	4·85	39·56	2·871
„ 16	Night	66·011	209·357	78·779	366·915	5·558
„ 17	Day	22·904	79·85	10·57	100·99	4·409
„ 17	Night	71·001	230·557	82·79	396·137	5·579

LAMPS, 16 NOMINAL C.P. PER INDICATED HORSE-POWER OF ENGINE.

Average for day (including October 16th)	4·357
„ „ „ (omitting „ „)	4·728
„ „ night	5·547
„ „ day, 24 hours, including October 16th ...	4·952
„ „ „ „ omitting „ „ ...	5·136

DISCUSSION.

JOHN W. HOWELL, C.E.: The Central Union Depôt in Cincinnati is lighted by an Edison isolated electric light plant. The plant is owned by local parties, who operate it and sell the current to the Depôt Company, the Depôt Company supplying steam and the owners of the plant supplying the lamps. The contract between these parties gives the Depôt Company the privilege of lighting the depôt for one week of each year with gas, and if this week's lighting costs less than the following week's lighting by electric light, then the price of electric light must be reduced in like proportion. About two years ago the Depôt Company lighted their depôt with gas for one week and with electric light for one week, as specified in the contract. This test was conducted by the Depôt Company themselves, and the results showed that lighting by electric light cost them 40 per cent. less than lighting by gas. In October, 1887, the Depôt Company had another comparison made, the entire conducting of the test being placed in the hands of the Cincinnati Gas Company. I went to Cincinnati to look after the interest of the electric light company, but was unable to secure any information as to the test proposed. The owners of the electric light plant were not recognised in this test; I therefore withdrew and watched the proceedings. Previous to the test, the electric light plant was shut down for eight days and the depôt lighted by gas, the gas company keeping a number of men on the watch to see that due economy was observed in the use of the gas. For the next eight days the depôt was lighted by electricity, the owners of the electric plant merely seeing that the same economy as to light was observed as during the preceding test. The cost of the electric light during those eight days was 10 per cent. less than that of the gas during the previous eight days. Consequently the owners of the electric light plant were not required to reduce the price at which they furnished the light. These tests furnished a direct comparison between the cost of lighting a given building with gas at $1 15 per 1,000 feet and with electric light. The same amount of light was required in both cases, and all conditions were the same. I think that it is to be regretted that the comparison instituted by Mr. Hill was not based on the actual result financially of these tests, instead of on the relative illuminating power of gas and incandescent lamps. A few words in explanation of the small number of lamps per horse-power shown by the test. The parties installing this depôt plant, to secure themselves against accident, put in two engines and counter-shafting, which enables them to use either engine to run the dynamos. This largely increases the friction, and the friction of the shaft is a practically constant quantity. Owing to the rigid economy used in burning the lamps during the test, the power measurements were taken with first, only about one-eighth load on the dynamos and second, with very little over half a load on; this not only puts the dynamo under its worst conditions of economy, but the large shaft friction being charged against a very small load, makes a very bad showing for the lamps. With the same lamps and dynamos used in Cincinnati, with a good load the Edison Company has often guaranteed eight lamps of 16 candles for each horse-power delivered to the dynamos. This guarantee has been frequently tested and has never been disproved. The Edison Company now sells lamps and dynamos with which it guarantees 12 lamps of 16 candles each for each horse-power delivered to the dynamos. This guarantee has been tested at two plants and in both cases the full number of lamps guaranteed was obtained. The first of these tests was made at Lowell by the company owning the water-power there, they using their own dynamometer and making the test themselves. The second test was made at the Toledo, O., State Asylum by State experts. In both cases the results showed a small margin above the guarantee—both showed over 12 lamps per horse-power delivered to the dynamos. Mr. Hill gives two measurements of horse-power and lamps, the first one about four and three-fourths lamps to the horse-power, with one-eighth load on the dynamo, and the second five and three-fourths, with half load. Full load on the dynamos ought to get seven or more. The larger the load on the dynamo the smaller the proportion of the total load is friction and the better the result. It is against the practice of the Edison Company to use shafting between the engine and dynamos. They always belt direct from engine to dynamo; this reduces the friction to a minimum. With a full load on the dynamo the friction of the engine and dynamo will be about 20 per cent. of the total load; with one-eighth of the load I would expect 40 or 50 per cent. of the total to be friction. In an engine running with one-eighth of its load, what would the friction be? What per cent. of the total? Mr. Hill notes a very great loss of energy between the engine and the electric light circuit, and it is due to this loss that the number of lamps per horse-power is so small. This loss is made up of two parts, the loss in the dynamo and friction. There have been a great many tests of dynamos published, all of which show the losses in dynamos to be very small. Losses by friction in engines and shafting are exceedingly variable, and depend entirely upon the condition of the bearings at the time. Mr. Hill assumes

the loss by friction, and by inference charges the remaining loss to the dynamo. Considering the very great uncertainty of losses by friction, and the ease with which it could have been measured, the assumption seemed decidedly unscientific. There is one other point. Where Mr. Hill speaks of the great variation in the light given by incandescent lamps, when making measurements of the candle light of the lamps, he gives the variation as 20 per cent., and he does not attempt to give any reason for it. There is only one thing that can make the lights vary, and that is the variation of the pressure on the line, and there are very few things that will make that vary; either very great changes in the load or in the speed of the engine. I am very well satisfied that the changes in the lights were due to changes in the speed of the engine. Any change in the speed of an engine will make the lights go up or down, as the case may be. When making measurements, if there are sudden changes, it is undoubtedly due to changes in the speed of the engine. We all know that an electric light is steady; we know that its steadiness depends upon the steadiness of the speed of the dynamo. Latterly, electric lighting has developed a type of engines that give better results than ever before. It is necessary in electric lighting to have a steady speed, and I think the alarm over the danger of variation in the electric light is not at all warranted. I think that in a large majority of cases they give a very steady, uniform light. As a lamp gets older it takes less power to run it, but it gives less light; the reduction in light is faster than the reduction in power necessary to run it; it takes more power per unit of light as the lamp gets older, but the lamp requires less power to run it.

JOHN W. HILL, M. Am. Soc. C.E.—The writer was engaged to make the investigation by the executive officer of the Depôt Company, and was informed, prior to beginning work, that his selection was reported to and approved by the officers of the Electric Company. If Mr. Howell, as he states, was present during the test, the writer can only regret that he did not make himself known and give him (writer) the benefit of his knowledge and experience in these matters. All of the data touching the cost of producing the light by the Edison system were taken jointly by one set of observers under direction of the writer, and another set under direction of the Electric Lighting Company, and he is not aware that any exception by the Electric Lighting Company has ever been taken either to the methods employed in making the test or in the accuracy of the data as reported. While it is true that the distribution of the indicated horse-power of the engines is not as accurate as it could have been by means of special tests (before or after the general tests) for friction of engine, jack shafts and dynamos — which tests, in passing, it is well to remark, were not admissible, owing to circumstances beyond my control—the main elements of the question, however, were carefully measured, *i.e.*, the power developed by the engines, and the electrical energy developed in the lamps. The steam engine indicators were in perfect working order, and the springs carefully tested for these experiments. The assistants in charge of the engine test were experienced and careful men. The motion of the engines was taken with reliable continuous counters, Schaffer & Budenberg make. The apparatus for the photometric tests was well constructed and worked by Professor French, with extreme accuracy in view; while the galvanometer was said to be one of the most perfect instruments in the country, and the readings were taken by a skilful electrician after a careful calibration in the test circuit to reconcile the effect of local disturbances. While it may be true that more of the loss between the engines and lamps should be charged to the engine and connectors and less to the current generator, the main fact which I wished to emphasise remains unchanged, viz.:—of the indicated power of the engines, which power is a direct and exact measure of the cost of producing the light, only 40 per cent. is realised in the illuminating effect of the incandescent lamps. It would no doubt be very interesting to know how this loss of about 30 per cent. is divided up, but no opportunity was afforded to do so in this test. The frictional loss in modern automatic engines and jack and line shafts has been so fully investigated by experimenters (the writer among others) that no serious mistake should be made in apportioning the power so expended under known conditions of service. The plates of the zinc voltameters were weighed by an employé of the Edison Light Company in my presence, and his determinations accepted as correct. The tests for quality of gas furnished by the Cincinnati Gas Company were made by Professor French of the Cincinnati University; and the tests for brilliancy of the electric lamps were made by Professor French, Mr. C. E. Jones (a local electrician), and the writer, and I am quite sure the prejudices of these gentlemen (if they had any) were in favour of the electric light. There was a test with gas for eight days with the following results:—

Cubic feet of gas consumed	214,700	
Cost at $1.15 per 1,000 cubic feet		$246.90
Average actual candle-power of the gas, for a consumption per hour of 5 cubic feet, as measured by Prof. French	16·94	
Average lights of 16 candle-power per hour for eight days	236·81	
Cost per light of 16 actual candle-power for eight days		1.04

From the test of the electric lighting plant, the data of which is all in the writer's possession, and for the accuracy and fairness of which he personally vouches, there were, as average effects for the eight days of the test, the following:—

Cost of lights as per the rate paid by the Union Depot Company to the Edison Electric Light Company (not including the cost of furnishing the steam to operate the driving engines)	$167.00
Cost of the steam, including all items of expense, which is borne by the Depot Company	101.32
Total cost for eight days	$268.32
Average hourly illumination by the electric light plant in lights of 16 actual candle-power each for eight days	185.15
Cost per light for eight days	1.45

From which, by the simple rule of three is deducted the increased cost of electric lighting over gas lighting of more than 39 per cent. The comparative cost of the two distinctive modes of lighting was not based on theory. The only facts in connection with gas which it is necessary to know to institute a comparison of cost, for equal effects of illumination, are the candle-power of the gas (which, in this instance, as has been stated in the paper, was carefully measured by Prof. French), and the cost of the gas per thousand cubic feet, which is $1.15 net. Having these data the comparison of cost can be made practically. The writer was not present during the test of lighting the depôt building with gas, and the quantity consumed during the eight days was communicated to him by the president of the gas company, General A. Hickenlooper, and the quality of the gas furnished by the gas company during the test of eight days was reported to him by Prof. French, and he has no reason to question the accuracy of either. But, assuming that the statement of the quantity of gas consumed is incorrect, this has no influence on the comparison of costs: the value of the gas, in candle-power, and its cost per 1,000 cubic feet, are all the data required to make such a comparison. Taking the actual data of the eight days' test with gas, and comparing with the data given in the paper, we have, by a different method of stating the case, the same relative results. In regard to the superfluity of shafting, of which Mr. Howell complains, there is one counter-shaft between the engines and the dynamos (and I think this is the usual arrangement employed with similar plants), to increase the speed from 230 at the engine to 1,150 at the dynamos. The engines were built by the Buckeye Engine Company, of Salem, O., which concern has had considerable experience in constructing engines for electric lighting plants, and these were rated at a maximum capacity of 50 indicated horse-power each, and were

operated during the test of eight days with an average load of 30·34 indicated horse-power each, or at three-fifths of the rated capacity, and not one-eighth, as Mr. Howell put it, the load on the engines being five times his assumption. The cylinders are 10 inches diameter, 14 inches stroke, and the engines, as stated above, operated at a nominal speed of 230 revolutions per minute. The fluctuations in candle-power of the lamps while under photometric test, I supposed at the time, were due to variations in the speed of the engines driving the dynamos; but as this variation seems to be unavoidable with driving engines as at present constructed, I cannot see how an apology for the defects of the engine is calculated to diminish this vicious and altogether objectionable feature of incandescent lighting. As to the merit of the writer's opinion on the injurious effect of an unsteady light or of rapid fluctuations and wide range of candle-power in any lamp upon the organs of vision, he who doubts its correctness is respectfully referred to any experienced oculist. I have taken the liberty of asking General Hickenlooper to give me a written statement of his knowledge of the motive of this investigation, and to correct or explain such matters in the discussion as were calculated to impair the scientific value of the facts presented in the paper.

The substance of his reply is appended as part of this discussion :—A. HICKENLOOPER.—Some of the statements by John W. Howell with reference to the competitive test of gas and electric lighting at the Grand Central Depôt in Cincinnati do not accord with my recollection of the facts. *First.*—As regards the statement that the Depôt Company made a test two years ago, and found that lighting by electricity cost 40 per cent. less than lighting by gas. The fact is that the Electric Light Company made the test, and neither the Gas Company nor the Depôt Company had anything to do with it. The result of the test, as published by the Electric Light Company, was that, on an eight night test, the gas cost $497 28. and the electric light $343 29. This test was made during the eight longest nights of the year. At the same rate per night this would make gas lighting for the year cost $22,703 94, but, in fact, the Gas Company did light the depôt for one year at a cost of $5,892. The cost of the electric light last year was $14,664 12. The statement that the last test in October, 1887, was made entirely by the Gas Company is not correct. It was entrusted to the experts, John W. Hill and Prof. Thomas French. As to the cost of the last test, the records show that for electric lighting the cost was—

For steam service	$102 03
The meters showed a consumption at contract rate of	167 00
Total	$269 03

while the same degree of illumination by gas required the use of 167,801 cubic feet, at $1 15 = $192 97. The total gas used on the premises during the gas test was 196,700 cubic feet, at $1 15 = $226 20. The conclusions regarding relative cost were not arrived at by taking the theoretical cost in either case. The actual cost of lighting by both gas and electricity was used.

THE GEYER-BRISTOL METER FOR DIRECT AND ALTERNATING CURRENTS.*

By Prof. WILLIAM E. GEYER.

THE following discussion took place after the reading of Prof. Geyer's paper, which we published last week :—

Prof. GEYER : The compound bar in its simplest form consists of two strips of metal soldered for their whole length and flatwise, these two metals having different coefficients of expansion. In the bar I have, the metals are brass and steel. The brass expands more than the steel, consequently the bar bends, becoming convex on the side of the brass. Thus I have here a bar which is practically straight : I heat it for a moment and the bar is very notably bent. If such a bar were heated by electricity it would also bend. The disadvantage of an instrument constructed in this way would be that it would also be a thermometer, and to make it simply a current meter would require the introduction of troublesome corrections. I will just for a moment call your attention to the instrument. You will see it has been recording for the time you have been here. By the kindness of the authorities here I have been furnished with current as you see, which here supplies a rack of lamps, and as I turn the lamps off and on you can notice that the pointer gradually goes down or up, leaving its record. The pointer does not respond instantly to changes of current, but as in actual use this record is spread over days, and in fact probably over weeks and months. This, I think, would not be a serious inconvenience. The clock that we have here at present causes that dial to rotate once in 12 hours. Of course, we might have a clock rotating faster or more slowly. If it had been convenient, I should have gotten one where the dial moved much more rapidly.

The CHAIRMAN : Gentlemen, I am sure we are all very grateful to Prof. Geyer for his clear and able exposition. The subject is now open for discussion. It is understood, I hope, that the discussion is not limited to the members of the Institute, and that we would be very glad to hear from any of our friends who are with us this evening.

Prof. MAYER : I was going to ask one question merely to illustrate farther what I have heard, that is as to the linear quantity separated from the plane.

Prof. GEYER : I have not estimated or tried to measure exactly what that quantity is. Our idea is to bring the wire, of course, very close to the centre line of the strip, but of course not going sidewise with the centre line of the strip. I have several bars here finished right off, passing the current through which the gentlemen are at liberty to examine. If you will give me just a moment, I might illustrate by drawing the relative position of the strip and wire. This (making a sketch) represents the strip. Let this represent the wire and then let this part be insulation. I have made it here unnecessarily thick. Then we have another portion of the strip. This then represents the strip, this represents the cross-section of the wire. This insulation I have made unnecessarily thick. That portion of this strip which has been driven to the rear side will, when the dies are brought down, pinch it on that side, whereas that portion of the strip will pinch it on the other side. I might state in an incidental way that these pieces of the strip are made unequally wide by the dies, so that as it runs down bringing pressure they are stretched up one a little more than the other, showing the wire outside of the centre.

Dr. WHEELER : I would like to ask Prof. Geyer what is the effect of changes of atmospheric temperature on the instrument.

Prof. GEYER : We have experimentally tried to find out whether atmospheric changes of temperature did affect it by taking it in the winter time from an ordinary heated room into a hall-way or passage-way where the temperature was below freezing, and then passed the same current as current by another instrument through it without being able to detect any difference in the reading. It is the difference of the temperature in the two bars which counts, not the actual temperature of either one.

Mr. F. B. CROCKER : I would like to ask Prof. Geyer if the moisture in the atmosphere had anything to do with it. The same question arises in regard to the Cardew voltmeter. I have never heard that question answered. Now every moist day, for example, this bar, which is intended to get hot, loses its heat more quickly than it does on a very dry day. In other words, would the difference in temperature be greater on a dry day than on a wet day ?

Prof. GEYER : On that point we have not made any experiments. I should judge from general principles, as it is simply the difference of temperature between the two bars, that the case would be analogous to the case that I mentioned before, putting the instrument into the warm room and then into the cold room; the moisture in the atmosphere, if it has any effect, being simply only equivalent to increased heat or increased cold around the instrument. Experimentally I could not say what the results would be, although I should imagine they would be negative.

Mr. CARL HERING : I would like to ask whether it would make any difference with this instrument whether the current were direct or alternating.

Prof. GEYER : It would make no difference whether the current were direct or alternating. What we measured is the heating effect of the current. We say an alternating current is equal to a continuous current for all practical purposes when it produces the same heating effect.

In answer to a question by Dr. Van der Weyde, Prof. Geyer said : The instrument as shown here is intended only as an ammeter, although we believe a voltmeter can be made. In this case it is necessary to introduce very high resistance. That we think we can accomplish by causing the current in one of the parts not simply to come down but to go back and forward a very great number of times. Thus instead of the wire which grows hottest in our present arrangement, we take a very fine wire—which, of course, it must be to make a voltmeter of—and bend it backward and forward a great number of times, and then lay that as a flat disc upon the other strip. (Illustrating.) The other strip having the current passing through it, or not passing through it, as may be desired. I found it would be heated anyhow by its proximity to the wire here; but there would be no difficulty, of course, in passing the current through this strip in addition to passing it through, zig-zag, back and forward.

Dr. VAN DER WEYDE : The objection to using the principle of expansion by heat as a voltmeter, is that currents of a very small

number of amperes have no heating effect. It is the amperes which cause the heat; the electromotive quality does not. For instance, in the old fashioned friction machine we have plenty of force; the electromotive force is very great. Prof. Mayer, in a lecture at the Stevens Institute, demonstrated that the number of volts of a static machine went up into the thousands. A voltmeter based on the expansion principle has a very limited range, and in fact it is but a metallic thermometer calibrated for volts. If you calibrate it for amperes it may be very correct. There is no doubt of it because the amperes cause the heat.

Prof. GEYER: Whether we say that it is the current that heats the wire or the electromotive force that heats the wire, to my mind is a mere question of words, because we ordinarily understand that it is the electromotive force that makes the current, so we could say the current heats or the electromotive force heats. The question as to whether a voltmeter will record so many volts, or so many volts, is to my mind simply a question of proper adjustment of parts. Thus, for instance, at the Stevens Institute we had occasion last summer to measure directly the electromotive forces of a Westinghouse alternating machine. We wanted to measure if possible directly without any multiplying devices, volts, say, from 10—go up to 500—we therefore constructed a voltmeter sufficiently long—in fact it was two stories high, and we had no difficulty whatever in getting very large deflections for 10 volts—that is as low as we cared to go, and we made our pointer go around nine times for 500 volts. To make no mistake in counting the nine turns we had a secondary dial, which, as on a common clock, rotated one division for each revolution of the other dial.

Mr. C. O. MAILLOUX: I would like to ask Prof. Geyer what is the rule, or law, or function of getting the deflection of the strip with the rate of current?

Prof. GEYER: In some respects it may be unfortunate that the deflections are not proportional to the currents. It would hardly be expected. As we all know the heating effect varies as the square of the current, so if I double my current I have four times the heat produced, but then the bars will lose their heat much more rapidly when they are at a higher temperature. The deflections are not then as the square of the current, but as some intermediate function. I have plotted out some curves, and if I had thought of it I might have drawn them on the board. I have not a curve here, but I might represent it, making a guess at it. Let the horizontal line (referring to a sketch) represent amperes, and let the vertical line represent deflections. If there were no increased loss of heat due to increased radiation from increased temperature, then, of course, our curve would be one rising quite steeply, and, of course, if the deflections are proportional to the current, our curve would be a straight line. As a matter of fact it is a curve between a straight line and the curve which rises as steeply as the amount of heat due to the law of radiation would require.

In reply to a question by Mr. Walcott, Prof. Geyer continued: It can be seen by noting the relative distance of the concentric circles what the rate of increase is for increased current. You will at once notice at the outside of the disc that the distance between two concentric curves is greater there, that the instrument grows more and more sensitive as the amount of current on it is increased.

Mr. CROCKER: I would like to ask Prof. Geyer one question, which I think has an important bearing on all meters, and that is as to the amount of current consumed by it compared with the amount of current that it measures—that is to say, the efficiency of the meter. I think these meters working by the heat produced—for example, Prof. Forbes's meter, and to a certain extent the Cardew meter, consume rather a large quantity of current in proportion to the current that they measure. For example, when 10 lamps are in circuit—we say 10 amperes—I would like to ask Prof. Geyer what the drop over the meter would be in volts.

Prof. GEYER: I agree with Mr. Crocker that the question of resistance is a very important one indeed, and we have aimed to keep the resistance of the ammeter low. The resistance of the bars which are here exhibited, is about ·06 of an ohm. We believe it could be brought much lower, possibly by using other metals. Probably the length of the bar might also be much shortened. When I tell you the resistance of the instrument is so much, you can calculate at once for any given current the loss of energy in the meter.

Dr. WHEELER: What is the ampere capacity of that ·06 strip?

Prof. GEYER: That strip will carry currents up to 20 amperes, and possibly greater. We have not urged it beyond that point. It can be made to any capacity by making the cross-section of the pieces greater. In the Cardew instrument, of course, great resistance is not an objection. It has always to my mind been one objection to the Forbes meter, that it consumes relatively a large amount of energy. He uses a very small proportion of the heat produced to operate a little windmill. We may be said to use the whole heat produced.

Mr. WALCOTT: With regard to the voltmeter which was drawn on the board, the reason why I asked my question was because it would require considerable length of wire, and I should judge the self-induction would be very high. That seems to be the trouble with using a straight wire.

Prof. GEYER: I think if the wire were wound zig-zag, the self-induction would, for that very cause, be eliminated.

Dr. MOSES: I regret to say, gentlemen, that I came late this evening. There are one or two questions that may be a little at random, but they are simply through ignorance, not having heard the earlier part of Prof. Geyer's lecture. Is there any superior advantage in having different radiating areas of the same metal over different radiating areas of different metals?

Prof. GEYER: The great point is that we have two strips whose co-efficients of expansion are equal, so that simple atmospheric changes shall not cause the bar to deflect. If, then, you select two different metals, which, however, have the same co-efficient of expansion, it will not alter the action of the instrument. The object of getting more radiating surface is to get a greater difference of temperature between the one conductor and the other conductor.

Prof. MAYER: The whole question resolves itself into this: The instrument comes very soon into equilibrium, although we may have different metals, so that it takes three times as much heat to heat one as the other. The radiation of the instrument will depend entirely on the difference between the plate and the surrounding surface; so that this question does not enter into consideration, in reference to the action of the instrument, so far as I can determine.

Dr. MOSES: One farther question. Do you believe it is possible to keep the surface at the same equal degree of polish, and in that way to be able to get equal ratios of radiation? Take German silver; the oxidation that will take place upon it from the increased radiating area of one side, may in that way affect its accuracy after a while, may it not?

Prof. GEYER: I think it would affect the rate of variation to a slight extent. We propose to use such a cross-section that the wire shall never lose its polish from simple heat generated in it. It would thus only lose its degree of polish gradually if subjected to severe treatment from without—say, strong acid fumes. Ordinary atmospheric changes do not seriously affect German silver.

Dr. MOSES: In the case of alternating currents have you considered the electric density, so to say, of the conducting body in relation to the differences of areas. That is a question that has recently been brought forward. Have you had time since its suggestion to look into the matter?

Prof. GEYER: I must confess my ignorance, and ask the Doctor to explain what he means by electric density. Then perhaps I shall be able to answer.

Dr. MOSES: I mean by that the fact that in conductors of different areas of cross-section there have been found to be certain parts of them that by an electromotive force set up within the body of the conductor itself it has been found to be like the central part of rods in mechanics in strains, that do not have the same ratio of conductivity owing to the sudden alternations of the current; the current not seeming to be able to permeate as it were to the centre. This difference in area might in some way or other affect the amount of current that would pass over the conductor wire and surface, and in that way somewhat affect the heat radiation.

Prof. GEYER: I thank the doctor for his clear explanation. I can only answer it as far as this—that I have lit up lamps with a continuous current and noted the deflection of the instrument, then heated them up to the same degree of brightness as measured on the photometer, and noticed the deflection when they were lighted by an alternating current of 16,000 alternations per minute, and could notice no difference in deflections.

NOTES.

The Electric Light at Leamington.—It is stated, upon what appears to be good authority, says the *Birmingham Post*, that the arrangements with the Electric Lighting Company are likely to be brought to a termination. Hitherto the company has lighted the Parade with the incandescent light, but the effect has not been satisfactory either to the council or to the public. A short time back the company supplied four arc lights, which were erected near the Town Hall, and a number of Sunbeam lights, which were placed in the top part of the Parade. The arc lights are by no means satisfactory; they fluctuate very much in the quality of light, and very frequently two, and sometimes three, are out. The Sunbeam is admitted to be a very good light, but the cost of supplying it to the whole of the Parade will be so great as to preclude its adoption. Under these circumstances it is probable that steps will be taken to terminate the contract with the company. The electric light supplied to the shops and private residences has been an unqualified success.

Electric Lighting at Woolwich.—We learn that the new central offices at the Woolwich Arsenal are being fitted throughout for the electric light. The work is being pushed forward with all haste by the contractors, Messrs. Drake and Gorham, in order that the lighting arrangements may be complete on the occupation of the offices early next month.

Bath and the Electric Light.—At the last meeting of the Bath Town Council Alderman Gibbs moved the adoption of a report from the Surveying Committee, recommending that the seal of the authority be affixed to a contract with Mr. Massingham for the electric lighting of a part of the city. He would, he said, have been glad if they could have dispensed with the posts and overhead wires. Mr. Sturges, in seconding, acknowledged that the friends of the electric light were exceedingly obliged to Alderman Gibbs for the great fairness he had shown in treating the subject in committee. He repressed their ardour, prevented their rushing, and had brought the vessel safely, he hoped, into port. Mr. Heywood wished the committee had seen their way to spend £240, and put the wires underground. He predicted that when they were put up there would be a howl of indignation, and that they would have to put the wires underground at any cost.

Central Station Lighting at Derby.—Messrs. John Davis and Son are now engaged in putting down at their works at Derby a plant for the supply of electric current for a block of buildings in the vicinity. The plant will be capable of maintaining 500 incandescent lamps of 10 C.P., or their equivalent. The supply of current will be from accumulators placed at the works, and will be available from dusk to 9 p.m., or later by special arrangement. The charge will be for a standard lamp of 10 candle-power, 25s. per annum, for a supply from dusk to 8 p.m. Other sizes of lamps and hours according to tariff. A guaranteed minimum rental of £5 per annum, that is four lamps of 10 candle-power, or the equivalent, is required.

The Electric Light at Buckingham.—The Market Square, Buckingham, has been lighted during the past week with a lamp of 250 candle-power, suspended on the front of Messrs. French and Son's ironmongery establishment, and, notwithstanding the density of the fog, the illuminating power of the lamp has been greatly admired. A number of business establishments are now lighted with the new illuminant, which gives general satisfaction.

Electric Lighting at Ipswich.—The first step was made by Messrs. Laurence, Paris, and Scott towards lighting Tavern Street, Ipswich, by electricity, on Saturday evening, when the establishments of Mr. John Driver and the City Clothing Company were brilliantly illuminated. Mr. T. Alderton's shop in the Butter Market was also lighted by electricity.

St. Alban's and the Electric Light.—The committee of the St. Alban's Town Council, appointed to enquire into the subject of public lighting by electricity, have practically suspended their labours. Two considerations chiefly have led to this. The St. Alban's Gas Company, awake fully to the situation, have made some liberal reductions in the price of gas; on the other hand, a little patience, it is thought, will give time for the improvement of the methods of public lighting by electricity.

St. Martin-in-the-Fields and the Electric Light.—At the meeting of the St. Martin-in-the-Fields Vestry last week a motion was brought forward to give consent, under rule 8 of the rules made by the Board of Trade, with respect to applications for licences and provisional orders under the Electric Lighting Acts of 1882 and 1888, to the granting of a licence by the Board of Trade authorising the Metropolitan Electric Supply Company, Limited, to construct and maintain electric lines and works, and to supply electricity within the parish. Mr. T. Hill moved that the consent of the Vestry be given, which was seconded by Mr. Churchwarden Challice, and adopted.

Bedford and the Electric Light.—The Town Council of Bedford has granted £25 to a committee of inquiry as to electric lighting.

Greenwich and the Electric Light.—At a meeting of the Greenwich Vestry last week a letter was read from the solicitors of the London Electric Supply Corporation, Limited, stating that they had received an intimation from the Board of Trade to the effect that, having regard to the importance of the question, and the conflicting interests which exist in the Metropolis, they thought it better that no powers under the Electric Lighting Act should at present be granted by way of licence, but that application should be required by way of Provisional Order, thereby coming more under the direct control of Parliament, and that, therefore, the licence for which that company had asked would not be proceeded with, but the Provisional Order, which was to take its place, would shortly be ready and would be submitted in due course.

The Electric Lighting Act.—Mr. Watt asked the President of the Board of Trade on Thursday last week whether the Electric Lighting Act of 1882 precluded the Board of Trade or local authorities from granting licences to one or more persons, firms, or companies to light the same area; whether the Act contained restrictions as to the breaking up of any street without the written consent of the Board of Trade; whether inquiries are made by the Board of Trade as to the ability of undertakers to carry out the work before licences are granted; whether he could state what number of licences had been granted since the last return was issued; and whether it was a fact that the reason assigned by companies which obtained licences under the Act of 1882 for abandoning these was the enormous law costs which would have been incurred owing to the opposition of the local boards or councils. Sir M. Hicks-Beach: The Electric Lighting Act, 1882, does not preclude the granting of licenses to one or more persons, firms, or companies to light the same area. With reference to the second question, the Board of Trade cannot give power to break up streets except under a licence or provisional order. As regards the third question, inquiries such as those suggested by the hon. member are made by the board of Trade. Two licences have been granted since the last report to Parliament. In reply to the last part of the question, I have to say that no such reason as that referred to by the hon. member has, to my knowledge, been assigned for the abandonment of licences. Mr. Rowntree asked the President of the Board of Trade whether his attention had been called to notices given for supplying electric light in the parish of Kensington, under the Electric Lighting Acts, 1882 and 1888, by the four following companies, viz., the Kensington and Knightsbridge Electric Company, Limited, the Chelsea Electricity Supply Company, Limited, the Notting Hill Electric Lighting Company, Limited, and the House-to-House Electric Supply Company, Limited; whether he was aware that the said companies proposed to conduct their operations mainly, or very largely, within the same area, and in many instances to take power to break up the same streets, roads, or places; whether it was the duty of the Board of Trade, before making any provisional order, to take cognisance, of its own motion, of such *primâ facie* objections; and whether the Board would not take any cognisance unless and until it was moved thereto by the local authority, or other parties interested. Sir M. Hicks-Beach: The answer to the first three questions of the hon. member is "Yes;" and the answer to the last is, that it is the duty and practice of the Board of Trade, in framing a provisional order, to consider any objections to which their attention is called, and also any such as may occur to them.

Mann's Telephonic System.—The directors of the National Telephone Company have made arrangements for having the present system of telephonic communication in Aberdeen replaced by Mann's circuit line system, which will necessitate an addition of 60 miles of wire, and the doubling of the operators' room at the central office.

Electric Lighting in Edinburgh.—At the last meeting of the Edinburgh Town Council the Library Committee recommended the acceptance of the estimate of Mr. Richard Millar, St. Enoch Square, Glasgow, for the electric lighting of the library amounting to £1,795, which was agreed to.

An American View.—The *Electrical World* has the following remarks with reference to the Deptford undertaking of the London Electric Supply Company: "An undertaking of this sort naturally brings with it considerable novelties of construction, and perhaps the most striking to be found in this particular one is the method, or rather the means, employed for the carrying of the current. We cannot but view with combined admiration and apprehension—admiration for the boldness, and apprehension for the success of—the employment of a potential of 10,000 volts, with one side of the circuit bare and exposed to ground contacts at innumerable points; in fact, designedly grounded. This means, in fact, an absolute insulation at every point in the circuit, and whether, in the light of past experience, even with currents of far less tension, such a state of affairs is a practical possibility remains to be seen. In fact, we can here only re-echo the statement of one of our foreign contemporaries, which remarks that this project must either be a gigantic success or a gigantic failure. For the sake of electric lighting generally, we hope that the scheme will prove successful. Mr. Ferranti, with the courage of youth, and borne up by firm conviction, has inaugurated a departure in electric lighting, which, if successful, must place him at once among the foremost electrical engineers of our time."

Cowpen and the Electric Light.—The *Blyth Examiner* thus writes upon this subject:—"The utter collapse of the Cowpen Local Board's negotiations for the electric light will fall upon many of our readers as a strange surprise. To us it is the natural outcome of the board's swagger—an outcome which we have all along anticipated. Our wonder is that the huge sham has lasted so long. The board, having abandoned an honourable public policy for one of narrow personal animosity towards the Gas Company, whose only offence has been that of success in its business, could not fail sooner or later to eventuate in a miserable failure. The cause of electric lighting never had a leg to stand upon. We also happen to know that if the Board of Trade Provisional Order had been gone for, the company were in a position to spring a powerful mine upon the whole affair, which would have left the contractors wiser men than they are to-day. It is better that they did not need to do so, and that the board, with ample rope, has at last hung itself. We have never denied that electricity may some day prove a powerful rival to gas for illuminating purposes; but we do maintain that that day is yet in the distant future, and that Cowpen is not the sanitary authority which should lead the way in such a hazardous experiment as that of introducing it to the country, while powerful corporations everywhere shun it."

Telephone and Fires.—The telephone has again proved its usefulness, says a "London correspondent;" it saved the Civil Service Stores from utter destruction last week. The watchman discovered a fire. Had he not been in communication with the fire station, the flames would soon have become ungovernable. The first five minutes is everything, say the firemen. In less than a minute they were placed in possession of the information, which enabled them at once to rush to save a very valuable property.

Mourlon Frères.—*La Cote Libre* announces that the firm of Messrs. Mourlon Frères is to be transformed into a company, under the name of the International Telephone and Telegraph Company. The capital is fixed at 1,000,000 francs, which it regards as comparatively small considering the standing of the house.

St. George's, Hanover Square, and the Electric Light.—At a meeting of the Vestry of St. George's, Hanover Square, on Thursday, December 20th, the Electric Lighting Committee recommended that an application from the London Electric Supply Corporation to light, with electricity, the area between Hamilton Place and St. George's Hospital, as far down Grosvenor Place as Halkin Street, be granted upon an agreement being entered into embodying the following conditions, viz.:—That the Corporation bear the whole expense of the laying of wires, &c., for making the experiment, and that a light quite as good as that now given by gas be supplied to the satisfaction of the Vestry, who will pay £300 per annum for the lighting of the area, the agreement to be for a period of twelve months certain, after which it should continue unless determined by three months' notice on either side. That the Corporation reinstate the parish lamps and paving, if removed or interfered with, to their present condition, and that no use of the parish lamps by the Corporation shall in any way interfere with their being lighted by gas, at any time, if so required, and the details as to the exact system of lighting be left to the Corporation." The Electric Lighting Committee recommended "That the Vestry resolve that it is in their opinion to the advantage of this parish, and so far as the Vestry could see, of the inhabitants of London generally, that joint stock companies should commence operations for electric lighting under licenses, rather than provisional orders." Lord Hobhouse in moving the adoption of this report said the company had already wires laid within this area. The expense of lighting the area by gas was about £300, and so they had fixed that sum in the agreement. Mr. Southon seconded the motion, which was agreed to with a rider prepared by Sir Walter Phillimore, regretting that the Board of Trade had refused to enter into the proposal of granting licenses on a principle which would seem to prevent any licenses in future being granted by them.

Growth of Telephone Business.—The messages transmitted along the United Telephone Company's wires on the 17th instant amounted to 103,428, the highest yet reached for any one day, while the messages for the week ending 18th instant summed up 586,294, being at the rate of 30,000,000 of messages per annum. The United Company is erecting a main trunk route to the north, and has already built half the trunk that is required to connect London with Birmingham. A main trunk to the west is also being surveyed and way-leaved, with the view of placing Bristol and the South Wales Coalfields in telephonic communication with the metropolis, while a new route to the south is in progress for the benefit of Brighton and the towns of the southern coast.

Telegraphic Communication with the Continent.—It is understood, says the *Daily News*, that a contract was signed between the Treasury and the Submarine Telegraph Company last week prolonging the agreement at present existing by which all messages from France, Belgium, and Germany pass through the hands of the Submarine Telegraph Company until March 31st, 1889.

Electric Light on Locomotives.—The experiments with the electric light on locomotives on the Berlin and Stralan-Rummelsburg railway have proved so successful that it has been decided to adopt this system on the Berlin ceinture railway.

Brevity.—We read in *La Lumière Electrique* that the Germans make use of a very convenient little word as call on the multiple telephone commutators used at central offices; it is:—"Fernsprechvielfachklappenschrauke"! This word has evidently been invented with the view of expediting the service.

New Cables.—In consequence of the interruptions of telegraphic communication with Australia, owing to volcanic eruptions and other causes, the Eastern Extension Telegraph Company have determined to lay a third cable from Banjoewangie to a point in Western Australia, probably somewhere near Beigle Bay. The length of the new cable will be over 1,000 miles. The Telegraph Construction Company is working night and day loading this cable into its ship, the *Seine*, which is to leave the Thames on Wednesday next to lay the cable. Mr. C. Riddle is the engineer in charge, and Mr. Thos. Clark is the electrician-in-chief. The Eastern Extension Company believe that when the cable is laid the chances of any breakdown in telegraphic communication with Australia will be very remote, and that they will be in a position to meet the competition of the new company which intends laying cables to Australia, *via* the Pacific. Another great cable of 700 miles is now being made by the Silvertown Company for connecting Loando with the Mossemedes on the West Coast of Africa, while the Telegraph Construction Company is making a cable of 1,500 miles to connect Mossemedes with Cape Town. This work will be completed in March next, and thus there will be two telegraphic routes to South Africa, one *via* the East and the other *via* the West Coast, an important boon in the event of any grave crisis again arising in that quarter of the world.

A contract of great importance was, the *World* hears, signed last week between the Government and the International Cable Company, which has its headquarters at Brussels, and in which Major Isaacs, M.P., and Mr. Sydney Gedge, M.P., are interested. A new Transatlantic cable will be laid to Bermuda and Halifax by way of Portugal and the Azores.

Index to "Electrical Review." — Owing to the Christmas holidays falling so awkwardly this year, we have thought it better to delay the issue of the Index for this half year until next week.

London Subways.—The Bell Telephone Company is doing in Philadelphia what all owners of overhead wires in London will have to do sooner or later, says the *Echo*. The Bell Company is constructing a conduit 3 feet wide through the main thoroughfares of the American city. This conduit will contain fifty 3-inch iron pipes, and fifty wooden tubes laid in cement. In this way accommodation will be provided for 10,000 wires. Connection will be made with each block of buildings by running a branch conduit to the centre of the block. In most blocks there are side streets or courts in which distributing poles can be fixed. Such an arrangement will not only free the streets from the dangers and unsightliness of overhead wires, but it will make communication far more simple and perfect, and avoid the delays and inconvenience which always result here after a snowstorm or heavy gale. The time is coming, if it has not already arrived, when something in the form of subways will have to be constructed to contain the gas and water mains which form so important a part of underground London. To get at these mains for repairs is a serious business. It involves great cost and much inconvenience to street passengers. One result is that these mains are not examined anything like so regularly and completely as they ought to be, and that means that the loss from leakage, especially in the case of water pipes, is very great. Another trouble is, that after a roadway or footpath has been taken up, it is impossible to make it good again, so that it will be level with the adjoining portions. The result is extra wear and tear all round. All these things involve charges upon the ratepayers and consumers. Costly examinations and repairs, and undiscovered leakages, have to be recouped out of the charges made to consumers. What is needed is that these pipes should be in subways where they could be readily got at without disturbing the surface. The first cost would, of course, be very heavy, but the after economy and convenience would be great.

Electrically Refined Sugar.—It is stated that the company which has undertaken the refining of sugar by means of electricity has been delayed in the development of the business, owing to some difficulties connected with insurance. At the latest trial of the process 50 barrels of the best crystallised white sugar were produced in 128 minutes. Experienced refiners who were present during the experiment were unanimous in praise of the quality of the sugar turned out. It is stated that the new process effects an enormous saving in labour. We are told that next year the company expects to turn out 2,000 barrels per day, and when in full operation the works will be able to produce 4,000 barrels per 24 hours.

Railway Diary.—Messrs. McCorquodale & Co. have just published their "Railway Diary and Official's Directory" for 1889. This is a most useful book for all doing business, or seeking to do business, with railway companies, or who are interested in such matters as traffic returns, accounts and dividends.

Accidents due to Lightning in France during 1887 :—

Objects struck.	Jan.	Feb.	Mar.	Apr.	May.	June.	July.	Aug	Sept.	Oct.	Nov.
Persons ...	0	0	3	0	7	2	5	3	0	0	0
Animals ...	0	0	0	1	0	39	55	2	0	0	0
Buildings, trees, &c....	1	0	2	4	7	12	42	4	1	1	0
Telegraph, wires, poles and stations	0	4	2	12	14	31	68	32	15	6	2

Persons killed, 3; injured, 17.
Animals „ 82; „ 15.

Priority in Telpherage.—Mr. R. M. Hunter, of Troy, Now York, writing to the *Electrical World*, claims to be "considerably ahead" of Professor Fleming Jenkin's dates of invention in regard to telpherage. An interference has long been in progress in the United States Patent Office between the Jenkin patent and Mr. Hunter's applications. He says he has practically worked the invention in America, and that foreigners will find it a difficult matter to have a word to say there in relation to electric railroading. The Ayrton and Perry patents, he further says, are of but little moment, while that of Jenkin is very broad.

Welding Works.—The Thomson Electric Welding Company is building new works at Lynn. The main building is 242 feet in length, by 87 in width. Power for these shops will be furnished by a pair of Greene engines, 42 × 20, to run at 100 revolutions per minute.

The Usefulness of Accumulators.—Owing to an accident to the steam plant in the residence of J. Pierpont Morgan, Thirty-Sixth Street and Madison Avenue, New York, some weeks ago, says the *Electrical World*, he was left without any means of illumination except candles, gas having been abolished some time previously, and as he expected to give a large dinner party the following evening, it was necessary to take prompt measures to remedy the effect. The Electrical Accumulator Company having a supply of accumulators for temporary lighting, and being appealed to, began the work of charging them at 4 o'clock in the afternoon, finishing at 12 o'clock noon the next day. The accumulators (60—"15 A" type) were then placed in crates, loaded on trucks, and carted from their Newark factory to Mr. Morgan's house (10 miles), set up with necessary switches and appliances, and at 6 o'clock the light was turned on, thus supplying Mr. Morgan with electric light in ample time for his entertainment. He has now arranged for a permanent installation of accumulators as an adjunct to the Edison direct lighting plant, a very wise step to take.

Electric Lighting Plant Wanted.—Tenders are required for the following plant:—To supply 10,000 8 C.P. 100-volt incandescent lamps. Boilers: Three 250 H.P., working pressure 160 lbs., to evaporate 6,000 lbs. of water each per hour, with hot feed. Pumps: Two double-acting, capable of supplying 1,800 gallons of water each per hour. Engines: Four compound, non-condensing, two of 180 I.H.P., one of 90 I.H.P., and one of 45 I.H.P., to be coupled direct to dynamos, to run at 450 revolutions. Dynamos: Four shunt-wound, two to give 1,000 ampères and 110 volts, one to give 500 ampères and 110 volts, one to give 250 ampères and 110 volts, at a speed not exceeding 450 revolutions per minute, and capable of running at 150 volts when charging the accumulators. Accumulators: Three sets of 60 cells each, capable of discharging at the rate of 500 ampères, and having a capacity of 1,000 ampère-hours each, mounted on suitable stands, with all connections, cables, &c. Switchboard: A switchboard, suitable for connecting up six sets of mains, four dynamos, and three sets of accumulators, with all necessary arrangements for charging and regulating. Tenders to be delivered by January 7th to the Secretary, Westminster Electric Supply Corporation, Limited, 2, Victoria Mansions, S.W.

Captain Cardew's Patents.—We understand that Messrs. Drake and Gorham have purchased the whole of the electrical patents held by Captain Cardew, R.E., with the one exception of his measuring instrument in America. These patents include not only the well-known Cardew voltmeter, but other devices in connection with central station lighting, which are likely to be in large demand. They do not propose to manufacture the apparatus themselves, but to licence a few firms of good standing to make under royalty.

Connecting Lighthouses.—The *Daily News* states that Sir George Baden-Powell has sketched a complete system of telegraph communication between the postal telegraphs and all the coastguard, lighthouse, lifeboat, and life-saving stations situated on the coasts of the United Kingdom. He intends to bring the subject under the notice of Parliament next Session, and to recommend the adoption of some such scheme with a view to the better prevention of loss of life and property in cases of shipwreck, for the general advantage of the shipping and fishing industries, and for the more effectual defence of the country in time of war.

The "Viscountess Bury."—A large party assembled on Thursday afternoon, last week, on board the new electric launch, *Viscountess Bury*, at Platt's Eyott, Hampton, to accompany her on her trial trip. The naming ceremony was performed by Mrs. Immisch. The trip was a complete success. Among the visitors were Viscount Bury, Lord Wantage, and Colonel Gouraud.

City and Guilds Lectures.—The "special" courses of lectures at the City and Guilds Technical College, Finsbury, for the coming term are as follows:—By Prof. Perry, F.R.S., "The Differential Calculus and its application to the practical problems of electrical and mechanical engineering"; by Prof. Silvanus Thompson, D.Sc., "Optical Principles and Practice"; by Mr. E. Rousseau, "Laboratory Course of Electro-deposition." Prof. Perry's lectures are intended for those who have no previous knowledge of the calculus. All these courses begin early in January.

Finsbury Technical College.—The authorities of the Finsbury Technical College announce that in consequence of the crowded state of the electrical laboratories entrance will be restricted to those who are actually employed in the electric industries, the only exceptions made being to admit students who have already taken the course at one of the local polytechnic institutions and now wish to proceed to the advanced laboratory instruction given at the Technical College.

The Electric Underground Railway.—We read that the trains of the City of London and Southwark Subway Company will be drawn by electrical motors of about 100 horse-power. The motors will be supplied with current by means of a sliding apparatus from an overhead cable.

OFFICIAL RETURNS OF ELECTRICAL COMPANIES.

Society of Telegraph-Engineers and Electricians.—At a special general meeting of this society, held at the Institution of Civil Engineers, 25, Great George Street, on the 22nd ult., the following special resolutions were passed, and were confirmed at a meeting held at 4, The Sanctuary, Westminster, on the 20th inst., viz.:—1. That the name of the society be changed to the Institution of Electrical Engineers. 2. That the office of Honorary Secretary be abolished, and that the articles of association be altered by omitting all reference to the honorary secretary in articles 36, 38, 40, and 43. These resolutions were duly filed on the 21st inst.

Crompton and Company, Limited.—The statutory return of this company, made up to the 13th inst., was filed on the 19th inst. The nominal capital is £140,000, divided into 20,000 preference and 8,000 ordinary shares of £5 each. 15,576 preferred shares have been allotted, upon 10,007 of which the full amount has been called, and £1 10s. has been called upon the remaining 5,569 shares. The calls paid amount to £59,029 10s., and unpaid to £2,988 10s.

CITY NOTES, REPORTS, MEETINGS, &c.

Maxim-Weston Electric Company, Limited.

AN extraordinary general meeting of this company was held at the Cannon Street Hotel on Friday, the 21st inst., for the purpose of confirming certain resolutions passed at a meeting of the company held on the 3rd inst. Mr. John Marks, chairman of the board of directors, presided.

Mr. Ramsay having read the notice convening the meeting,

The Chairman moved the confirmation of the following resolution, without comment: "That the Maxim-Weston Electric Company, Limited, be wound up voluntarily."

Mr. L. Swaby seconded, and the resolution was carried with four dissentients.

The Chairman next moved the confirmation of the resolution appointing Messrs. John Marks, J. M. Klenck, and L. Swaby, liquidators, for the purposes of the voluntary winding up.

Mr. Hildyard seconded the motion.

Mr. M. Abrahams (solicitor to Mr. Hugh Watt, M.P.) said there was only one observation which he wished to make. At the meeting held on the 3rd inst. several other resolutions were tacked on to this one. He did not observe that those resolutions were mentioned in the notice of that meeting, and concluded that they had been abandoned.

The Chairman: These are the only resolutions which we are called upon to confirm to-day.

Mr. Abrahams: The others are abandoned then?

The Chairman: Well, then, I will say yes to that.

The resolution was carried with three dissentients. A second extraordinary general meeting was then held for the purpose of considering, and if thought fit, passing other resolutions.

The Chairman, in proposing the first, said: Mr. Abrahams has just raised the question as to whether we have abandoned the terms upon which we intended that the liquidators should sell to the new company, resolutions regarding which were carried at the last meeting. Since that meeting we have been advised by very eminent counsel that the terms upon which the sale should be conducted are those embodied in the agreement, the draft of which we have here, and which will be read to you.

Mr. Ramsay having read the draft agreement, a lengthy document, setting forth in great detail the conditions under which the sale was to be effected,

The Chairman said those provisions and clauses had been settled by eminent counsel, who had kept in view the rights of all parties. The principal clause was that which had reference to the allotment of one share in the new company for every share held in the old company, and it also made due provision for dissentient shareholders up to 30,000 shares. Should the dissentients hold more than that number of shares, it would be within the rights of the directors to say that they would not go on with the scheme, but proceed simply with the winding up of the company. He moved: "That the liquidators of the company be and they are

hereby authorised to consent to the registration of a new company to be named the Maxim-Weston Electric Company, Limited, with a Memorandum and Articles of Association which have already been prepared with the privity and approval of the directors of this company."

Mr. J. M. Klenck seconded.

A Shareholder asked what was likely to be the amount of the liabilities which, under the second clause of the agreement, shareholders of the new company bound themselves to meet. It was a very wide clause, and seemed to make it almost an unlimited liability company.

The Chairman said he stated at the last meeting that the liabilities of the old company amounted to between £2,000 and £2,500, and the good book debts were equal to the amount of the liabilities, so that they might regard their patents and plant as being unencumbered.

Mr. Henderson said he should like to hear what price the liquidators were prepared to offer dissentient shareholders. He would like also to know whether, in the case of the price being fixed by arbitrators, the arbitration would be at the expense of the company or the dissentient shareholders.

Mr. Abrahams said he had been consulted by a great many shareholders—holders of more than 30,000 shares—who meant to intimate their dissent from that resolution. There was power, under the 11th clause of the agreement, for the liquidators not to carry out the programme if holders of 30,000 shares dissented. He could not ask them what they would do in case of that number dissenting, but would intimate to them that they would probably receive notices of dissent from more than 30,000 shares. A shareholder had asked what price the liquidators would give dissentient shareholders. As he (Mr. Abrahams) said at the last meeting, the directors had already fixed the price. They gave shares nominally of 3s., with 2s. paid; therefore the fixed price of the shares at 2s., and that he contended the arbitrators would give. Possibly the arbitrators might not agree, and in that case an umpire would have to be appointed, and it would be for him to say what should be paid. His opinion was that the sum would be 2s., but he was not the umpire; he was a litigant and an advocate. He was a shareholder to a small extent, and he was going to ask for 2s., and his clients, representing more than 30,000 shares, would ask for it. He had carefully read a copy of the agreement, and he thought it was in all respects a fair agreement. There was one point with which, however, he found fault. Under one clause the liquidators were entitled, at their discretion, to retain possession of all or any part of the property until the dissentient shareholders had been satisfied. The liquidators here were the directors, and he thought it should be compulsory for them to retain possession of the assets until they had paid the dissentients.

The Chairman said, in reply to Mr. Henderson, that the claims of the dissentient shareholders would be submitted to arbitrators. They did not anticipate that the arbitrators or the umpire would give anything like 2s. per share.

Mr. Klenck said the matter should be regarded as simply a transfer of the property from one company to another. If they wound up entirely they would lose the goodwill of the business. The highest bidder would get the assests and the remnant of goodwill, which would be sold to him without any reference to the shareholders whatever. By carrying out the scheme submitted, they would soon dispose of the dissentient shareholders, for it was quite certain that as soon as they found that the price of the shares on the market had gone up from 2s. to 2s. 6d. they would sell their shares in the market in preference to claiming 2s. through the arbitrator. It was not to the interest of the shareholders to dissent, but to support the scheme and pull it through. As soon as they got the company on a proper, sound commercial basis, with credit at the bank, and money in its coffers, they would be ready to receive the business which they had been obliged to decline.

The Chairman said they pinned themselves to the agreement, and would not go from it.

Mr. Newton said that it did not follow because a shareholder voted for the resolution that he committed himself to taking shares in the new company. He still had a right to appeal to the arbitrator.

The resolution was carried with six dissentients.

The Chairman then moved:—"That the draft agreement submitted to this meeting, and expressed to be made between this company and its liquidators of the one part, and the Maxim-Weston Electric Company, Limited, of the other part be and the same is hereby approved and that the said liquidators be and they are hereby authorised pursuant to Section 161 of the Companies' Act, 1862, to enter into an agreement with such new company (when incorporated) in the terms of the said draft, and to carry the same into effect with such, if any, modifications as they think expedient."

Mr. Hildyard seconded, and the resolution was carried, five shareholders dissenting.

A vote of thanks to the chairman terminated the proceedings.

Metropolitan Electric Supply Company, Limited.

AN extraordinary general meeting of this company was held at Winchester House, Old Broad Street, on Friday last, Sir John Pender, M.P., in the chair.

Mr. E. Cunliffe Owen (the secretary) having read the notice convening the meeting,

The Chairman said: Gentlemen, we have called you together to-day for two purposes: to inform you as to the progress the company has made since August last and as to its present position and prospects; and secondly, to put before you a resolution approving an agreement made by the board under the powers of the articles of association to vary the original agreement entered into between this company and the Whitehall Company for the purchase of the property and undertaking of the Whitehall Company. And first, with respect to the work done, you are aware that the company took over from the Whitehall Company the important works and installation they had established at Whitehall and the Avenue Theatre. That installation, which is about 10,000 lights, was opened on October 5th last, and the directors had before hoped that the full capacity for lighting would be taken up by customers in seven or eight months; instead of this the full capacity of the station is taken up already. In about two months orders were booked for nearly 9,000 lamps, and the mains for connecting them are being laid. The Avenue Theatre, the Hotel Victoria and other places have been lighted for some time, and the managers have written expressing their perfect satisfaction with the supply. Among the more recent contracts secured are the Grand Hotel, Messrs. Hampton's large furniture warehouse in Pall Mall, St. Martin's Church and other places. The company's mains are being laid underground throughout the whole of the Charing Cross district, and have already been laid across Northumberland Avenue without any appreciable inconvenience to the traffic. Mr. Gordon informs me that the guaranteed revenue for the contracts made for the works was £13,500, and that further contracts amounting to a further £1,000 will be completed in a short time, making altogether £14,500. The working expenses, including rent, salaries, wages, are estimated at £6,000, leaving a profit of £8,500 a year on this installation, which, I think, is fairly satisfactory, seeing that the capital represented by these works is not much over £40,000. The Sardinia Street Station we have arranged for. That is a very important station. It embraces important residential property, and some important newspapers are published in the neighbourhood. That district will have, I think, altogether 50,000 lights, and, so far as we can see now, judging from the enquiries, it will not be a very long time after the installation is completed before that will be fully occupied, and if the results from those 50,000 lights are satisfactory in proportion to what we are now seeing from practical working in Whitehall, we may congratulate ourselves upon being in the position of making very handsome dividends. I may mention that the machinery for this station has been ordered from the Westinghouse Company, and the bulk of it will be delivered very shortly. The object, gentlemen, of ordering this of the Westinghouse Company is this: that they have put down in America 116 installations. All those installations have been successful, and the principle we have gone upon, and what has been the policy of this company—because we have not been idle during the past six months—has been to take the very best thing in existence, to utilise that for our purpose, and to bring against the American system, which is almost perfect as far as it has gone, some competition. We are inviting tenders from English contractors in order that we may have the advantage of what I may call contractors' competition. I think the result of that will be to give us the best thing of the kind up to the present moment. I do not mean to say in electricity, as in other things, there is not very great progress. Ten years ago the electric light was merely experimental; it has now become almost universal. It is not more than 25 years since submarine telegraphy was first introduced; there are now £40,000,000 sterling at the bottom of the sea, paying a fair dividend, thus showing that we do not know to what extent electricity may be carried; but this we know, that the time has come when electric lighting is becoming the light of the future. I have no hesitation in saying if you refer to the prospectus you will find that prospectus was based upon a good deal of experience. You will find that what we said in regard to the American installation ought to be borne out also upon English soil. The company also took over the extensive and very valuable property for electric lighting purposes, the Waterloo Bridge Wharf, which is admirably adapted for supplying the lighting of the Strand district, and which can take the machinery required for working 150,000 lamps. That, I think, will probably be the largest installation in our system. We want you to understand, gentlemen, we have not gone in the slightest degree on a speculative or experimental policy. We are laying down installations which we know will be successful, so far as the mechanical part of the business is concerned, and we believe they will be taken up by the public. I think we are not over sanguine in looking forward to a very successful future. The installation, I hope, before another year is out, will be in active operation. We know there are very formidable competitors in the market at the present moment. I allude to the enterprise—I may as well name it—of the Grosvenor Gallery combination. The gentlemen connected with it are of the highest eminence; they have great practical scientific knowledge amongst them; they have the biggest experiment ever tried in electric lighting, and I hope it may be successful. I hope to see these great efforts of science successful. That is, I believe, a very valuable step in electrical progress. We have been more cautious—probably more prudent; we are not putting all our eggs in one basket. We are arranging our installations so that they are not likely to break down. Every installation will stand alone, or shoulder to shoulder with its neighbouring installation, if required. Since August, as I have said, we have not been idle. The directors have secured several other sites for works—one a large

wharf adjoining Southwark Bridge. We have also obtained a site in South Mews, Manchester Square, for Marylebone. With regard to the Strand district, the company have secured the monopoly for the lighting of the new Salisbury estate. That will be one of the most important improvements, and I hope we shall light that. I cannot say much more on the point of our prospects. In the summer it was said they were encouraging; I thing if I were to go over, item by item, every item in the prospectus, I could justify everything that has been said. Now, gentlemen, the second part of the business I hope will also be satisfactory, because it is very much for the company's interest, although probably not so much for the benefit of others who have been working two or three years, and consider themselves very badly paid. Now, I must say at once, that the short result of what we have shown you to-day is to reduce the purchase-money payable for the property by the company; to reduce it from £79,000, the sum named in the prospectus as having been named by the vendors, to practically half, to the very moderate sum of £40,000. This, as I say, you will see is practically reducing the purchase-money one half, and I am sure that everyone here will be glad that that reduction is to be made. The vendors are willing to make the reduction, although they are by no means satisfied with the decision which those eminent gentlemen, Sir Frederick Bramwell and Sir Whittaker Ellis have arrived at with respect to the value of the property. It was, of course, to be expected that the vendors would take a more favourable view of their undertaking than what I may call cold-blooded valuers. The vendors made arrangements with the company when there were no shareholders but themselves and their friends, and it did not seem necessary to do more than to see there was a substantial basis for the price to be paid. No man could then, nor could he even now, estimate absolutely what is the value of the undertaking we have purchased. I have told you of our prospects; probably a year hence our stock may be worth twice or thrice what it is to-day. Therefore you see the difficulty of valuing a thing which is not realised. In this valuation I believe nothing has been taken into consideration as to the valuable and favourable prospects of the company. But one thing is, I think, clear—that the valuers have not taken into consideration what was largely in the minds of the vendors, and that is what I have just stated. I do not know what was in the minds of the valuers. They have, wisely perhaps, given no reason for their decision; but, from the course of inquiries which they made very carefully in respect to the properties actually transferred and the prospects for the future, I have no doubt they omitted from their calculation these elements of future value, which the vendors not unreasonably considered to be so important. I may add that the vendors will be perfectly willing to take back their properties if the company do not desire to go on with the purchase; but I believe I am quite justified in saying that every member of the board is convinced that the property is well worth, and more than worth, the sum we now decide to pay for it. There is one other item, gentlemen, also to be mentioned, and that is with respect to the Provisional Orders which the Board of Trade had guaranteed the vendors before the prospectus was issued. These Provisional Orders gave to the company valuable rights over the parishes of St. James's, Westminster, and St. Martin's-in-the-Fields, and when the Duke of Buckingham refused to suspend the Standing Orders, which prevented the second reading of the Government Bill to confirm the Provisional Orders, the Board of Trade promised to use their good offices to support a private Bill to enable the company to secure the confirmation of the Provisional Orders in the next session. In consequence of this, I think the valuers must have made a large reduction from the original price. In conclusion, the Chairman said that the South Metropolitan Company was threatened with opposition by the Whitehall, and that was what really brought them together. He moved a resolution for the purpore of "confirming an agreement dated 12th December, 1888, made between the board of directors of the company of the first part, and Sir John Pender, Sir George Elliot, Joseph Charles Parkinson, Esquire, and the Whitehall Electric Supply Company, Limited, of the second part, for varying the agreement dated July 17th, 1888, referred to in the articles of association (clause 6), and made between the South Metropolitan Electric Supply Company, Limited, of the one part, and the Whitehall Electric Supply Company, Limited, of the other part, by which the said Whitehall Company, for the consideration therein mentioned, agreed to convey and assign to the South Metropolitan Company its undertaking, property and rights as therein mentioned."

Alderman Sir R. N. Fowler seconded the resolution, which was carried.

The Chairman added that the company had given notice of a Bill in Parliament to obtain parliamentary power to carry on the works of St. James's, Westminster, St. Martin-in-the-Fields, and Waterloo Bridge, which would include the ground covered by the Provisional Orders obtained last summer. They had also given notice for Provisional Orders in various other parts of London. He added that the directors viewed the prospects of the company as very encouraging.

A vote of thanks to the chairman and directors then terminated the proceedings.

London Electric Supply Corporation, Limited.

THE second ordinary general meeting of this company was held last Friday at Winchester House, Old Broad Street. The Earl of Crawford and Balcarres presided.

The Chairman, in moving the adoption of the report, stated that they took over the installation at the Grosvenor Gallery in 1887, there being then about 11,000 lamps. The directors of the previous company spent a considerable sum in order to place their dynamos and engines in a very advantageous position; and they contracted with the engineer to supply dynamos sufficient to give the current to 20,000 lights. It was afterwards found, when the two machines were put into position, that the nominal efficiency of 20,000 lights could be safely exceeded, and the present company came into possession of two dynamos capable of giving 30,000 lights. In addition to that there was a system of engines which was very complete, but the engines were not quite sufficient for the large amount of work demanded from them at present. They had purchased a large system of overhead mains—cables for conveying the current from the generating station to the houses of the consumers. A good deal had been said as to overhead mains, but the directors had every confidence in their system, as the best material was used, and the work was efficiently done. To satisfy the Board of Trade as to the efficiency of their wires, they took one down which had been up for three years and seven months, and after it had been thoroughly tested in the presence of the officials of the Board of Trade, the latter acknowledged that it was in perfect condition. At Deptford they had a dynamo with an engine capable of giving 25,000 lights, and they had every reason to hope that would eventually be equal to supplying 30,000 lights at least. They had also arranged for another dynamo of 25,000 lights. They would eventually have a capability of 150,000 lights, with a reserve power of 100,000 lights. He thought he might state that they had the whole circuit of London open to them. The only question was how much per mile they were to pay, and he thought they might trust the directors to arrange for that as cheaply as possible. He exhibited a map showing the various districts in London for which they had applied for provisional orders, and which practically embraced more than half of the metropolis. They had asked for powers to deal with the streets in twenty-four different localities, under the jurisdiction of as many local authorities. He expressed his confidence in the future of the company.

Sir Coutts Lindsay, in seconding the motion, said he believed that the working of the previous company would conduce to the success of the corporation, in the prosperity of which the directors held an overwhelming interest.

The Chairman said, in reply to a question, it was probable that the Metropolitan Electric Supply Company had applied for provisional orders in the same districts as themselves. The resolution was carried unanimously.

On the motion of the Chairman, seconded by Lord Wantage, a resolution was afterwards passed authorising an increase in the capital of the company by the creation of 50,000 new shares of £5 each, the holders to be entitled out of the profits of each year to a preferential dividend at such rate as the board, before the issue of the shares, should fix, but without a right to any further participation in profits, the holders to be entitled within five years from the 31st inst. to give up the preferential rights in the shares, if fully paid up, and the shares then becoming ordinary shares.

Charles L. Baker and Company, Limited.

THE second ordinary general meeting of this company was held at the Registerd Office, Booth Street, Manchester, on Tuesday last, December 21st, 1888, Mr. J. E. Longson in the chair.

Mr. George W. Lowcock, the secretary, having read the notice convening the meeting, the report and accounts were taken as read.

The Chairman said that the directors had much pleasure in meeting the shareholders and laying before them the account of the first year's working. This they considered very satisfactory, considering the business had been in the hands of the company so short a period. They had pleasure in recommending a dividend at the rate of 10 per cent. per annum on the ordinary shares, and 5 per cent on the deferred shares. The business of the company had largely increased, and they were sure that the shareholders would be gratified to learn that they had secured several valuable contracts which would keep the works fully occupied for some length of time.

Messrs. Trevor and Pilling were re-elected auditors, and a vote of thanks to the chairman concluded the meeting.

Eastern Telegraph Company, Limited.—This company announces the payment, on January 14th next, of interest at the rate of 3s. per share on its preference shares, less income tax, for the quarter ending December 31st, 1888, and on the same day an interim dividend will be paid of 2s. 6d. per share in respect of profits for the quarter ended September 30th, 1888, on the ordinary shares of the company, free of income-tax.

TRAFFIC RECEIPTS.

The Western and Brazilian Telegraph Company, Limited. The receipts for the week ending December 21st, 1888, after deducting the fifth of the gross receipts payable to the London Platino-Brazilian Telegraph Company, Limited, were £5,268.

The Brazilian Submarine Telegraph Company, Limited. The traffic receipts for the last week amounted to £6,370.

RUNNING ELEVATED RAILROAD TRAINS BY ELECTRICITY.

QUITE an interesting electrical experiment, says the *Scientific American*, took place on the rainy night of November 27th on the Ninth Avenue elevated railroad in this city, being a trial of a new Daft electric motor, named the Benjamin Franklin, weighing about 10 tons. Its four wheels are connected for the purpose of increasing the tractive power. Notwithstanding the driving rain, it hauled a train of three regular elevated railroad cars very easily up heavy grades for a mile and a half. At the end of the route the motor switched off, backed, and hitched on to the other end of the train, with the same facility as with the steam locomotive; in fact, it seemed to be done with greater ease. The total weight of the train was estimated at 60 tons. The current was supplied from dynamos located in a station in Fifteenth Street. The electrical current is conveyed from the station and alongside of the track by a copper rod $\frac{5}{8}$ of an inch in diameter. The current is taken from this rod into the motor by a metallic brush, which presses upon and slides along the rod. The trial was undoubtedly a severe one, inasmuch as the rails and connecting rod were saturated with water. A number of prominent railroad engineers, officials, and electricians were present, and were perfectly satisfied as to the result of the trial. It appears to be only a question of time when our city elevated trains will be hauled as rapidly by electricity as with steam.

The *Electrical Review* * says :—"In the power station four dynamos, of 50 horse-power each, supply the current, and a fifth, of smaller size, serves to light the place. The power dynamos are connected with a switchboard, which permits of their being used 'in parallel' or 'in series,' as may be desired, without trouble or delay.

"These terms merit a word of explanation, as the first of them describes a disposition which is an important factor in the economical generation of dynamo electricity. When two machines are connected—both positive poles to one leading wire, and both negative to another—they are said to be 'in parallel,' and the current obtained is greater than the sum of the currents of both working separately, in direct ratio to the reduction of their internal resistance brought about by the coupling.

"This arrangement may be carried further, but with a rapidly lessening degree of advantage. Coupling machines 'in series' consists in passing the current of the first through the second, and so on.

"An important instrument is the automatic cut-off, which is brought into play by the occurrence of a 'short circuit' on the track, and opens the *ketee*, or chain, as our German friends term it, at a fixed point, sounding at the same time an alarm. This contingency, which might befall through accident or mischief, would have the effect of unduly lessening the resistance, and so increasing the quantity of current that it might develop enough heat in the insufficient circuit to destroy the insulation of the field magnets and armature coils, and disable the machines.

"The steam engine that drives the generators is of 250 horse-power, and the potential of the current developed 280 volts, a step beyond that used at Baltimore, but still within the danger limit.

"The illustration of this article shows the Franklin with a four-car train. In her experimental runs she has repeatedly drawn this train with less than three-fourths the current-generating capacity in use, up and down the line at a speed of 25 miles per hour.

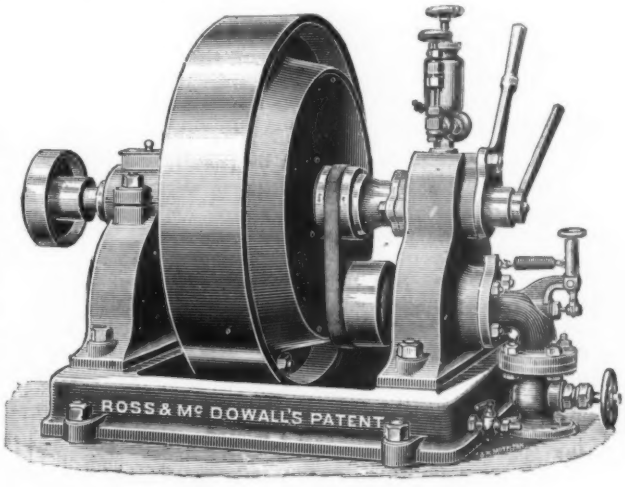
"With the same current and three unloaded cars a speed of 30 miles per hour was kept up uninterruptedly for a long time.

"The commercial outcome of the achievements of the Franklin could hardly be forecast; but, in consideration of the well substantiated claim that the substitution of such motors on the New York elevated railways would reduce the running expenses about 50 per cent., and this even when including, as a fixed charge, the interest on the cost of re-equipment, and also without allowing any rebate for the sale of the present steam locomotives, which are of standard gauge and available on any ordinary track, there should be little doubt as to the probable line of action of such a sagacious and far-sighted management as that of the New York elevated railways."

* New York.

THE ROTA ENGINE.

AT the Glasgow Exhibition Messrs. Glen and Ross exhibited a rotary engine, designed by the inventors, Messrs. Ross and McDowall, to attain a high speed of revolution with a relatively slow piston speed. It consists of a narrow cylindrical casing of cast iron with closed sides, mounted on a shaft supported in two standards, one on either side of the cylinder. The shaft is hollow, and has ports for the admission and eduction of steam, the interior space being divided longitudinally to form admission and exhaust passages. A cylindrical boss is formed eccentrically upon the shaft within the casing; the inlet and exhaust ports passing through it to the working steam spaces. This construction does away with any passages which can remain filled with steam after cut-off has taken place—a fruitful source of waste in ordinary engines. Inside the main casing, and concentric with the boss, is fitted a cylindrical ring, the annular space between it and the boss being partially filled by a series of segmental pistons. The pistons are held in equal



angular positions relatively to the axis of the main casing, to which they are connected by means of slides working in radial slots formed in the casing; and as their distance from the axis varies according to their position round the eccentric boss, their distance apart also varies, those pistons bearing on the boss, having least eccentricity, being close together, while those on the opposite side are further apart. As the pistons travel round the eccentric boss, their speed is highest at the point of greatest eccentricity, and the ports are arranged to admit the steam between each pair of pistons just after they pass the point of least eccentricity and to exhaust as they pass the point of greatest eccentricity of the boss. The steam, however, can be cut off at any desired point, and will expand while each piston is impelled forward at a greater relative velocity than that following it, so that the intervening space becomes greater until the line of greatest eccentricity is reached, and the exhaust from between that pair of pistons takes place. Each succeeding piston, as it comes round, is acted on in like manner, and a continuous rotary motion is thus imparted to the outer casing, the inner ring being free to rotate with it, and accommodating itself by sliding within the main casing to the radial sliding movement of the pistons relative to the

axis of the casing. The central hollow shaft is held stationary, while the main casing forms a flywheel revolving upon it; but with reversing engines the casing is attached to the bed-plate, the shaft alone revolving.

The engine shows some ingenuity, and is well made, but it is questionable whether it will prove to be better than other rotary engines already in use. For dynamo driving it has certain defects in common with other engines of the same class; but for driving fans and other purposes, where high speed and moderate power are required, it might be preferred to others, on account of the little space it occupies, and its neat appearance.

THE SPECIFIC RESISTANCE AND OTHER PROPERTIES OF SULPHUR.*

By JAMES MONCKMAN, D.Sc.

Resistance.

IT is well known that sulphur in a solid state insulates electricity of very high potential, and conducts heat badly; also that it undergoes a curious series of changes when heated—melting at about 120° C., becoming thicker at 200° to 250°, more liquid at 250° to 300°, and boiling under atmospheric pressure at 440°. During the past three terms I have been engaged in the Cavendish Laboratory in trying to determine whether these changes are accompanied by corresponding ones in the electrical resistance and other properties of the element.

Two platinum wires were placed in a beaker of melted sulphur at a distance of about 1 cm. apart, one being connected to an electroscope, the other going to earth. When the sulphur became solid the leaves of the electroscope remained open on charging for a considerable time, but fell at once if any portion of the sulphur between the wires was liquid.

The same experiment was tried with paraffin, and the discharge found to be very slow.

Seeing, then, that the resistance was removed by melting the sulphur into the region of conductors, it became necessary to find some method that could be used for conductors of very high resistance.

Platinum and gold electrodes being found unsatisfactory, some graphite rods which had been procured from Hogarth and Hayes, Keswick, for some experiments on carbon, were tried, and a perfectly constant flow of electricity, even at the boiling point, was then obtained.

When the sulphur was melted (125° C.) 60 volts gave a deflection with a reflecting galvanometer of 11,770 ohms resistance of only half a millimetre on the scale, while at 440° C. one cell gave a deflection of 60 mm.

The general results obtained were as follows:—

Resistance.—Ordinary roll brimstone:—

Temperature.	Potential.	Deflection.	Reduced to one standard by multiplying by 60/c.
440° ...	2½ ...	60 ...	1,560
300 ...	„ ...	12·5 ...	325
270 ...	„ ...	2 ...	52
250 ...	„ ...	1 ...	26
250 ...	55 ...	10 ...	24
223 ...	... ...	3 ...	7
195 ...	60 ...	6 ...	6
150 ...	„ ...	5 ...	5
140 ...	„ ...	2 ...	2
125 ...	„ ...	0·5 ...	0·5

Another specimen gave slightly different numbers, but of the same order.

With pure precipitated sulphur the resistance was considerably higher.

Pure sulphur:—

440° ...	4·1 ...	35 ...	512
350 ...	„ ...	5 ...	73
335 ...	... ...	3 ...	44
335 ...	8·2 ...	7 ...	51
290 ...	54 ...	5 ...	5·5
280 ...	„ ...	2·5 ...	2·8
260 ...	„ ...	0·5 ...	0·55
125 ...	... ...	could get up a swing only	...

* Abstract from the proceedings of the Royal Society.

The specific resistance calculated from these tables, gave 5,600,000 nearly, or 5×10^6 ohms at 440°; at 260° it is nearly 1,000 times that number, or 5×10^8.

Roll sulphur gives the same resistance at 125°, that is, 5×10^8; while at 440° it is one-third pure sulphur, or $1{\cdot}6 \times 10^6$.

Action of Light.

That the metals of the same group in the arrangement according to the Periodic Law have properties in common is well known. Thus chlorine, bromine, and iodine belong to the same group, and are in many respects very similar bodies. Sulphur belongs not only to the same group as selenium, but is the next element in front of it. Naturally, therefore, we expect that they will have properties in common, and possibly the action of light in the case of the former may be shared in an inferior degree by the latter. This appears more probable from the well known fact that a saturated solution of sulphur in bisulphide of carbon is rendered turbid by direct sunlight. Part of the sulphur being changed and becoming insoluble in that liquid. A portion of the sulphur undergoes the same change when exposed to a high temperature. In order that the sulphur used in the experiment might be as sensitive as possible to light, it appeared desirable that only pure soluble sulphur should be used, and that great care should be taken not to raise the temperature in melting it so high as to produce any of the insoluble modification.

Two rectangular graphite rods were placed parallel to each other, the one projecting about an inch at one end, the other at the other end.

The edges were turned towards each other, leaving a space of one millimetre, which was filled with melted sulphur. This was levelled off with a hot iron to make the portion between the corners as thin as possible.

A quadrant electrometer was charged, and the graphite rods, separated by sulphur, inserted between the binding screws, so that the negative quadrant was connected with the positive one through the sulphur (1·5 cm. long, 1 mm. thick, and 1 mm. broad).

The electrometer was charged to the same potential in each experiment in a series, and allowed to run down for a certain time. Sunlight was allowed to fall on the sulphur, but shaded from the rest of the apparatus; when not required the ordinary window blind was drawn down.

Of course the electrometer and sulphur were protected from induction by surrounding bodies by wire screens.

The following three series of readings were taken on different days, and in one or two cases clouds interfered with the experiment, especially in No. 8, when the light was considerably shaded by cloud.

		Scale deflection at the beginning.	Time.	Fall in scale divisions.	State.
			minutes.		
1st series	(1) ...	180	30	20	Dark.
	(2) ...	„	15	20	Light.
	(3) ...	„	35	18	Dark.
2nd series	(4) ...	300	15	25	Light.
	(5) ...	„	17	25	„
	(6) ...	„	15	20	Dark.
	(7) ...	„	15	19	„
	(8) ...	„	15	20	Light.
3rd series	(9) ...	200	15	14	Light.
	(10) ...	„	15	17	„
	(11) ...	„	16·5	16	„
	(12) ...	„	15	10	Dark.
	(13) ...	„	15	10	„

The first and second series were alternated dark and light in the same set of experiments to see that no permanent change was produced and mistaken for the effect sought. In the first the time varied, and the deflections were allowed to fall the same distance; in all the others the time was the same, and the fall varied.

The method of performing the experiments made it

possible that the effect might be produced by the heat of the sun and not by the light. The variation in temperature observed on a delicate thermometer was about 1° C. To eliminate the effect of heat, a long series of observations was made in the dark, whilst the temperature was raised slightly by placing a Bunsen flame four or five inches away from the screen protecting the sulphur, and the heat radiated by placing an iron spiral in it, then one of copper, and lastly a fine clay tile.

The range of temperature was 15·2° C. to 17·1° C. in the first ten experiments, in which the heated ones fell rather more slowly than those at a lower temperature. In the next seven observations the range was 14·8° C. to 18° C., the fall being exactly the same in each.

There yet remained the possibility that the light falling on the wires which held the rods caused the charge to escape more quickly into the air. When, however, the sulphur was removed, the effect produced by the light on the portions of wire exposed to its influence was too small to produce any change in the rate of fall.

Hence it appears that although selenium is the body most sensitive to the action of light, it shares its property with its neighbours, and the three elements (constituting the same group), sulphur, selenium, and tellurium, are all similarly acted upon, furnishing another example of the importance and beauty of the law which classified them together.

ELECTRICITY AS TRACTIVE FORCE.

By ROMAN, BARON GOTSKOWSKI.

IN the Honigmann locomotive a chemical process was used in order to heat the boiler, but this is evidently a circuitous process, since the chemical energy of the caustic-soda dissolving in water might be directly converted into work without the intermediate link of steam, as, *e.g.*, it is the case in galvanic batteries.

As a matter of course, elements like those employed in telegraphy are not available for this purpose, since, independently of the cost, they work far too slowly.

If I ask a telegraph engineer what time is required to consume a kilo of zinc in a telegraphic element, he would reply that at least six months would be required. Half a year is 4,000 hours. Now I want to consume a kilo of zinc in an hour, but this is possible only if the resistance in the element is reduced 4,000 times. There are, in fact, such elements—the well-known accumulators.

Tramlines are already in existence in which the electricity is conveyed to the motor by the rails or by a special conductor. The motor is fixed in the car whilst the machine yielding the current remains stationary at one point.

Such tramlines are, however, scarcely admissible for practical work in busy streets, since on this plan all cars on the same line are exposed to any disarrangement which may happen in the machines or the conductors. It must further be considered that the conveyance of the current to the moving cars involves difficulties, in as far as it pre-supposes a good insulation of the conductor, but the rails, as they cannot project above the general level of the street, cannot be readily insulated. The use of a conductor supported on posts above ground is admissible only where the traffic is small or where one side of the road can be given up to the tramlines. Lastly, it must be considered that the working of such motors involves a waste of power.

At great distances the loss both of current and of potential increases very rapidly. In case of ascents, on the other hand, the fixed machine producing the current must be arranged to yield as much electric energy as is required to drive the cars up the greatest inclines. If after such an ascent there follows a level or a descent, the energy supplied may often be greater than that needed to propel the cars at a normal rate. To prevent this excess of energy from being injurious an artificial resistance must be introduced which cannot be economical, since in such a case the electric current produced at a certain expense is converted not into mechanical work but into useless heat. As this under normal conditions always happens in the most favourable parts of the line, it is evident that the greatest part of the way is traversed with a waste of power. But that the losses of energy are very serious appears from the fact that on an incline of 13·6 millimetres per metre the resistance to be overcome is twice as great as on a level. Consequently, in cases where the electric car passes from such an ascent to a level, the half of the energy supplied must be converted into useless heat.

Compound machines are here useless, since we have not to compensate fluctuations in the strength of current due to changes in electric resistance of the conduction but fluctuations arising from variations of the speed of rotation of the axle of the motor, the resistance of the conductor remaining unchanged.

Again, regulators which alter the position of the brushes according to the rotatory speed of the motor are of no use, as they are only able to compensate trifling differences of the speed of rotation, whilst the changes in working tramlines are very considerable.

Finally, it must be remarked that when several cars have to run simultaneously upon one and the same line very strong, and consequently costly conductors must be used or dangerously high potentials must be admitted.

If such difficulties are to be encountered, and if those losses of energy which increase directly as the length of the way traversed are to be avoided, the supply of the current by conductors must be renounced, *i.e.*, the current must be produced in the car. Galvanic elements are excluded, because these generate the current at the expense of the dissolved zinc, and are, therefore, at least 13 times as expensive as appliances which produce the current at the expense of burning coal, since 13 lbs. of coal are required to produce 1 lb. of zinc from blende, and the current obtained in both cases is approximately equal.

Such arrangements for obtaining the current at the expense of burning coal are accumulators.

Working Capacity of Accumulators.

In the manner in which they yield mechanical work, accumulators are in no manner distinct from ordinary galvanic batteries. In accumulators there take place chemical processes resembling those which occur in galvanic elements, only there we have zinc and copper, but in the accumulators we have lead and peroxide of lead.

The chemical process itself has not been quite clearly explained, but most probably the substances on both the plates are converted into sulphates.

The sulphuric acid in which the metallic plate of lead (Pb) and the plate of peroxide ($Pb\ O_2$) are immersed, effects immediately the decomposition of water. Its oxygen passes to the lead forming oxide of lead (Pb O), whilst the hydrogen at the peroxide of lead takes up part of the oxygen which it here encounters, forming water ($H_2\ O$), and reducing the peroxide ($Pb\ O_2$) to oxide (Pb O). The formation of lead oxide from lead yields for each gramme equivalent of lead 36·9 calories, the combination of the lead oxide formed with oxide of lead to sulphate of lead ($Pb\ SO_4$) yields 11·7 calories. The entire heat produced by the element is therefore: (36·9 + 11·7) = 48·6 calories.

But as the decomposition of lead peroxide into lead and oxygen requires an expenditure of 6·1 calories, there results from the chemical processes taking place in the accumulator a heat of (48·6 − 6·1) = 42·5 calories.

We obtain, therefore, for each equivalent (expressed in grammes) so much heat as is needed to raise 1 kilo of water from 0° to 42½° Centigrade.

If an accumulator evolves K calories for each gramme equivalent of lead, it yields mechanical work of 425 . K kilogrammetres.

In order to separate out a gramme equivalent of lead, there is needed a current of nearly 10^5 ampères, the current of 1 ampère yields, therefore, work of $\frac{425 \cdot K}{10^5}$ kilogrammetres.

If the potential at the terminals of the accumulator is e volts, the work which the current of 1 ampère performs under such circumstances can be represented by the expression $\frac{e}{g}$, in which $g = 9{\cdot}81$ metres represents the acceleration due to gravity, and the supposition is admissible that the entire heat becomes current energy, and the accumulator takes up no heat from without.

In such a case we have the equation :

$$\frac{e}{g} = \frac{425 \cdot K}{10^5}$$

whence follows

$$e = \frac{K}{25}.$$

Prof. Waltenhofen in his work on electrical measurements uses the formula

$$e = \frac{A \cdot f}{10^8} \cdot K.$$

If into this formula we insert $A = 4{\cdot}15 . 10^7$, $f = \frac{1}{10^6}$, then

$$\frac{A f}{10^8} = \frac{1}{25}$$

and we arrive at the formula developed above.

The potential at the terminals of an accumulator yielding 42·5 calories for every equivalent of lead expressed in grammes, must according to the above presentation amount to $e = \frac{42{\cdot}5}{25} = 1{\cdot}7$ volt.

But as it amounts in fact to 2·25 volts, it follows either that the above suppositions are not quite accurate or that the chemical processes follow another track.

If the current furnished by an accumulator is sent into a wire or a glow lamp, the potential at its terminals would remain approximately constant during the efflux of the electricity. But this is not the case when the discharge is effected into an electromotor, because the electromotor evolves a counter E.M.F., the consequence of which is that the mean tension at the terminals sinks during the discharge to about 89 per cent. of its former value, and is therefore only 0·89 × 2·25 = 2 volts.

As the resistance of the accumulators constructed for tramway purposes is 0·0074 ohm, we should expect from such an accumulator a current of $\frac{2}{0{\cdot}0074} = 270$ ampères, and considering that an accumulator of this resistance weighs 42 kilos a current which per kilo of total weight amounts to

$$\frac{270}{42} = 6{\cdot}4 \text{ ampères.}$$

If, however, so much electricity per kilo of its weight has really been obtained from an accumulator per second without injuring it, we must bear in mind that less electricity can be obtained from an accumulator by a rapid discharge than by a slow one.

In discharging, the sulphuric acid which has been absorbed by the positive plates has to be replaced by fresh acid out of the liquid. But as the speed at which this process is effected depends on the strength of the current, the case may arise that the supply of acid is not effected with the necessary rapidity, and that consequently less heat or energy is produced than would be the case if the demand for electricity were more or less intense.

If the process of discharge is interrupted so that the accumulator plates remain for a moment at rest, we obtain when the circuit is again closed an electromotive force and a strength of current rather stronger than it was before the interruption. This behaviour of accumulators makes them exceedingly suitable for propelling cars on tramlines, because in working such lines interruptions of the journey and consequently cessations of the out-flow of the current occur.

From these and other reasons we should, according to Waltenhofen, take in practice from an accumulator per kilo of its total weight not more that 1 coulomb of electricity and consequently be able to work with no current stronger than 1 ampère. The energy which we have to expect per second and per kilo of the total weight of an accumulator is therefore practically

$$2 \times 1 = 2 \text{ watts,}$$

that is

$$\frac{2}{9{\cdot}81} = \tfrac{1}{5} \text{ kilogrammetre.}$$

For how long such work per kilo can be obtained from a battery of accumulators will evidently depend on the quantity of electricity stored up in the apparatus.

It has been already mentioned that in order to separate a milligramme equivalent of a substance 100 coulombs of electricity are required. But as the electric equivalent of lead is about

$$Pb = 103$$

that of litharge is

$$Pb\,O = 111,$$

hence, in order to separate 1 milligramme of lead, we require $9{\cdot}10^5$. coulombs. But as likewise the spongy lead of the negative plate formed from 1 kilo. of litharge is converted into sulphate of lead on discharging, we may say that for decomposing 2 kilos. of the filling mass $9{\cdot}10^5$ coulombs are needed. One kilo. of such mass requires, therefore, a quantity of electricity equal

$$\tfrac{1}{2} \times 9{\cdot}10^5 \text{ coulombs.}$$

As the charge of an accumulator generally makes up one-third of its total weight, the quantity of electricity corresponding to one kilo. of the entire weight of an accumulator is

$$\tfrac{1}{3} \times \tfrac{1}{2} \times 9 \times 10^5 = 15{\cdot}10^4 \text{ coulombs.}$$

Each kilo. of an accumulator battery can therefore store up such a quantity of electricity if it could in practice be charged to this extent.

This, however, cannot be done, as we are not able to effect the chemical conversion of the entire mass, since a portion of it must be kept inactive in order to cement the active mass to the lead plate, which is effected by converting a part into sulphate of lead.

The converted part of the mass also cannot be entirely utilised, as we do not wish to leave an electric car entirely devoid of energy even when it is not in motion.

The quantity of electricity, and that of the energy which can be practically derived from an accumulator per kilo. of its total weight, may be seen from the following table, which is compiled on the basis of the results of Prof. Waltenhofen :—

From this table, which refers to the tramway accumulators of the English E. P. S. Co., it may be seen that in general we cannot obtain more than 20,000 coulombs of electricity per kilo. of the total weight of an accumulator, although 150,000 coulombs, *i.e.*, 7½ times as much may be stored up in it, and that not more than 4,000 kilogrammetres of work can be obtained per kilo. of total weight.

Model S. No.	Total weight in kilos.	Strength of current in ampères.	Capacity. Electricity. Ampère hours.	1,000 Coulombs.	Energy. From 1 kilo. weight of accumulator. Ampère hours.	1,000 Coulombs.	Watts.	Kilogrammetres.
7	11	8	48	173	4	15	28·8	3·0
11	15	13	78	281	5	18	36·0	3·6
15	19	18	108	389	5	18	36·0	3·6
23	27	25	150	540	5·5	20	39·6	4·0
31	36	35	210	756	6	22	43·2	4·4

By the total weight of the accumulator we understand the weight of the battery, the sum of the lead plates, of the active mass, the acid and the containing vessels. In the Reckenzaun batteries these weights are as follows :

Lead plates	16·0	kilos.
Active mass	7·9	„
Acid	6·9	„
Containing vessels	3·7	„
Total weight	34·5	„

We may assume that the active mass weighs half as much as the plates, whilst the latter make up one third of the total weight of the battery.

The Weight of the Accumulator Battery.

The weight of the battery, which must be accommodated in a car, depends on the amount of mechanical work which the battery has to perform in propelling the car.

If the car weighs G tons, and has to be propelled at the rate of c metres per second upon a line which presents to every ton of the weight propelled a resistance of w kilos., the work to be performed is $G \cdot w \cdot c$ kilogrammetres.

But since experience shows that the electromotor reproduces only 80 per cent. of the work which it receives, the accumulator battery must every second supply to to the electromotor an energy of

$$\frac{G \cdot w \cdot c}{0{\cdot}8} = \frac{5}{4} \cdot G \cdot w \cdot c$$

kilogrammetres. As every kilo. of the weight supplies to the battery per second $\frac{1}{5}$th kilgrammetre of work, a battery weighing a tons will yield per second a work of $1000 \cdot \frac{a}{5} = 200 \cdot a$ kilogrammetres.

Hence we have the equation :

$$\frac{5}{4} \cdot G \cdot w \cdot c = 200 \cdot a,$$

or

$$G \cdot w \cdot c \cdot = 160 \cdot a,$$

from which we may calculate the weight, a, of the accumulator battery as soon as the weight, G, of the car to be propelled is expressed as a function of the weight of the accumulator battery.

If the passengers weigh P tons, and if the weight of the empty car is W, and the weight of the electromotor is E tons, we have :

$$G = (W + P + E + a) \text{ tons.}$$

Since a car which is to convey more passengers and a heavy battery must be built more strongly than a car for fewer persons and a lighter battery, and as the weight of the empty car must increase with its strength, W will be a function of P and a. The weight of an empty car may be 0·7 of the weight of the passengers which it is to carry, and 0·1 of the weight of the accumulator battery to be introduced. We have then

$$W = 0{\cdot}7\ P + 0{\cdot}1\ a.$$

If we assume the weight of a passenger as 70 kilos, and if the car carries n passengers, then

$$P = \frac{70 \cdot n}{1000} = \frac{7}{100} \cdot n.$$

If we further consider that E may be = 0·6 ton, and that $w = (13{\cdot}6 + m)$, whenever m indicates the incline of the line in parts per thousand, we obtain, starting from the speed $c = 2{\cdot}8$ metre, and from the equation given at the outset :

$$a = \left(5 + \frac{n}{10}\right) \left[\frac{13{\cdot}6 + m}{38{\cdot}3 - m}\right] \text{ tons.}$$

From this formula it appears that the weight of the battery depends on the incline of the line, and must vary for every gradient.

The smallest weight of the battery will be that for a level, and it is found by substituting $m = 0$ in the above formula; it will be $a = 0{\cdot}36 \left(5 + \frac{n}{10}\right)$ tons.

A car accommodating 50 passengers, in order to travel on a level at the speed of 2·8 metres, will require a battery weighing 3·6 tons, whilst one of three tons will suffice for a car built for only 30 passengers.

As it is impracticable to adapt the weight of the battery to different gradients, and as it is necessary to traverse different gradients with one and the same battery, a weight must be selected once and for all for the battery.

If this weight were selected so as to correspond to the steepest gradient on the line, we should then be able to traverse such an incline at the prescribed speed of 2·8 metre per second. But this would involve the disadvantage that the easier gradients would have to be ascended at a higher speed, and that there would be in such parts of the line a useless excess of energy. This is to be avoided, as such an excess is tantamount to an excess in the weight of the battery, which is very uneconomical.

We see from the above formula that inclines exceeding 38·3 in the thousand cannot be traversed at the speed of 2·8 metres, as even for such an incline the weight of the battery would be infinite.—*Zeitschrift für Elektrotechnik.*

(The conclusion of this memoir is announced for a following number.)

COMPOUND-WINDING PATENTS.

KING, BROWN & CO. *v.* ANGLO-AMERICAN BRUSH ELECTRIC LIGHT CORPORATION.

(*Continued from page* 708.)

Sir WILLIAM THOMSON giving evidence, cross-examined by Mr. GRAHAM MURRAY.

You pointed to page 11, line 20, where a machine is described with a large number of bobbins in one group, and in the answer you gave did not you assume that the opposite magnetic poles in that passage are not opposite in the sense in which the term is generally used?—Yes.

Now, would you look at the drawings, figs. 13 and 14?—I find great difficulty in understanding this. I have tried to mark the poles, but as far as I can understand it the meaning of the directions seems to be this: to spread out the polarity a little, to widen the field, which would be done now by giving projecting horns to each pole. I think that Varley thought he had not made any new theory at all, because he makes no claim to it, and I think it was an unfounded impression of his that his method could be confounded with Cromwell Varley's.

You said you found, in connection with fig. 17, the direction that the machine was to be series wound. Now, does that drawing show anything more than this, that it indicates by the line denoting the current that the current has not to be brought back to the supplementary commutator, and that it shows also the

place where the winding is to be put in?—Yes, it shows where the winding is to be put in. It is a drawing of a machine doing work through an external circuit, and the current which does that work passing round the magnets.

And shows that the machine is working series?—Yes.

Now, there is only one direction for winding given in the specification. I think at page 8, line 38, taking that winding, is not that a winding which is necessarily exclusive of pure series winding?—It excludes the idea that the magnet is only the external circuit wound round it—that there is a second wire wound round it—not pure series in the electric circuit, but excludes the idea that that is the only current that acts on the magnet.

In this case we have been using the term pure series as meaning the winding, which is a series winding, and the machine which is net wound in any other way at all. Viewing series in that sense, this is exclusive of series?—Yes.

I will now come to the machine. You said it was experimental, because it had a lot of terminals. Of course, that would not prevent it working in any way? It would not be a disadvantage?—No; but it would require to be shown how they were to be used.

Now, if you were told that this machine (Varley's) was worked with this lamp, and that it was noticed that when the lamp was lighted the magnetism of the machine gradually increased from what it had been before, would that convey to your mind that this lamp was used in connection with a series coil of this machine which went round the field magnets?—Yes.

If you were also told that when the lamp was out the magnets of the machine were noticed to be excited, as evidenced by keys and things sticking to them, and also by sparks at the brushes, would that indicate to your mind that the magnets of this machine, besides being excited by the series arrangement, were also excited either by a shunt or by separate excitation arrangement?—No, because your magnetism would be amply sufficient to produce these effects, and if there was any steel in connection with the soft iron magnets, it would be so much more.

If a machine was pure series there would be no use for the second wrapping on the magnets at all?—No.

Assuming that that commutator is electrically connected just from end to end, to form a continuous circuit, that would exclude, I suppose, the idea of the separate excitation from a portion of this armature?—If there are three bobbins in a group here, and a treble commutator, then it would exclude separate excitation, so far as I can judge at present, and it would exclude a separate exciting circuit.

Re-examined by the DEAN OF FACULTY: I do not think the reading of lines 38 to 40 on page 8 by an experienced workman would exclude series winding. Supposing "electricity" were held to mean electrical energy, the description would include all separate exciting machines and series machines. I can conceive an ordinary workman not understanding it at all. Looking at drawing No. 17 and the description on page 11, line 50, I think that description indicates series winding only. I notice there are four terminals under the armature of Varley's machine.

Re-examined by Mr. MURRAY: Would you kindly look at line 41, "two insulating wires, one having a larger resistance than the other." Now can you conceive of any useful object to be attained by having the wires of different resistance unless it was for a method of bifurcation?—Yes, if it was for a method of separate excitation—five groups, four of these groups joined in parallel to do the external work, and one group having each to excite the magnet—that would naturally work into the wire of very high resistance round the magnets.

Why not have a wire of no resistance round the magnets?—Because the resistance is so much lower in the other groups round the parallel.

Well, you are taking away the whole of the electricity by your separate group for the purpose of excitation of the magnets, and that is not effected by what you are doing with the electricity moved to the other groups?—The quantity there would be a collection of what comes to the external circuit, so a thick wire would convey four times the current the other wire gives.

As I understand a machine arranged in that way, four groups of bobbins would divert electricity and would go to the external circuit, one group would go to separate excitation. Now there would be no electrical connection between the one group of bobbins and the other?—No.

WILLIAM HENRY PREECE was the next witness. Interrogated by Mr. JAMESON, he said: I am electrician to the General Post Office, and the scientific branch of the Post Office is under my charge. I reside in London, and I have the superintendence of the whole telegraphic department in the United Kingdom and Ireland. I am also a member of the Council of the Royal Society, and a member of the Council of the Institution of Civil Engineers. I am president of the mechanical section of the British Association. I have been associated with the practical applications of electricity since 1862. I visited the United States officially for the Government in 1877. There was no electric light to be seen there at that time. In 1884, when I again visited America, an immense development had taken place. All the principal towns in the United States were lighted by electricity, and Brush's system met with very considerable extension. I visited the Paris Exhibition in 1878. Electric lighting had commenced to make a start in France by that time, and there was a fair display of electric light in the exhibition. There was no shunt machine exhibited at Paris then. The Brush system has been very extensively used in parts of the United Kingdom, particularly since 1880. I lectured on electric lighting in the Albert Hall in May, 1879, before a very large assemblage of people—there were 7,000 people—and there was a large display of apparatus, though not a single shunt machine. My attention was first called to the shunt machine in 1880 by a paper read by Sir William Siemens before the Royal Society. I was aware that Sir Charles Wheatstone had read a paper before that time, developing the idea of the shunt; but Sir Charles, in his paper in 1867, simply alluded to the experimental use of the shunt, and did not indicate the construction of the machine. I had not heard of Clark's patent before 1880. As far as I know, no machine has been made in conformity with that patent. I visited the Paris Exhibition of 1881. The shunt machine was fully developed there. I was a member of the Council of the Inventions Exhibition in 1885. There was not a shunt machine shown there by Mr. Varley.

His LORDSHIP here interposed, and said this history might be all very interesting, but he did not see the necessity for going into so many details.

I have seen Mr. Varley's machine, No. 29. I do not consider that it is an economical machine. It is very complicated and a machine of excessive waste, indeed. The machine is so constructed that it must seriously waste the energy put into it, by a steam engine or any other power, enormously. If that machine were used to excite the electric light it would require 4 horse-power, of that 3¼ would be wasted in the machine, and ¼ horse-power only would be employed in generating the light. I find that Mr. Swinburne gave the resistance of the armature at 9 ohms, of the coil of lower resistance, 2 ohms, and of the higher resistance, 10 ohms. Outside the machine there would be a lamp, similar to the lamp 42 of process, and generally we may assume that such a lamp would take 6 ohms, and, working these figures out, I bring out by calculation that the result would be 3¼ horse-power wasted in the engine in the machine and ¼ horse-power utilised outside. It is possible to couple up Varley's machine in different ways. I think that it would be extremely difficult, if not impossible, for a workman in 1876 to have constructed a machine from Varley's specification. The descriptions are very various and very complicated. There are two or three different machines described. The whole thing is really an improvement upon a machine that existed and was patented before. The drawings are scarcely consistent with the letterpress, and there is nothing throughout the whole specification, as far as I can see, which would enable an ordinary workman to construct a machine according to any one of the descriptions given by Mr. Varley. Especially so do these remarks apply to that part of the specification which deals with the question of winding with two wires on page 8. And here the language is certainly inconsistent with the rest of the specification. There are 2-pole machines, 4-pole machines, and 6-pole machines, and they are all referred to as though they were ordinary series-winding machines. But when we come to the description from line 35 to line 48, in page 8, dealing with the question of two wires, we find there is something that is not consistent with anything else that appears in the specification. But it is to some extent consistent with part of Varley's specification. It was very well known that about this period Holmes and Wilde excited their machines by separate circuit taken from a part of the armature, and in the previous specification of Mr. Varley of 1867, you will find at pages 61 and 62, pages 2 and 3 of specification, that they did use two wires with the electro magnets. The wrapping of magnets with two wires was no novelty in 1876. It is used for numerous purposes, especially in connection with duplex work, and a workman would have had no difficulty in performing that work, still less now. It would not necessarily follow that he would be able to construct a series shunt machine, because the construction of a compound wound machine involves a good many other questions. You have to know the character and type of the machine, the work it has to do, the speed at which it was to rotate, and to determine the ratio between the resistance of the armature and the series and shunt wires. I have tried to make the description consistent, and the only possible system that I can find effective in Varley is the idea that a second wire is excited by the operation of the bobbins of the armature. I consider the machine described in Haddan's specification is a useful machine. It is used very extensively for electro-plating, and it has been extended for electric lighting. That is the series shunt system. It has been a decided improvement on the series and the shunt in point of simplicity.

Would a workman, from Haddan's specification, have any difficulty in constructing the machine?—I think not. Such a machine as was indicated by the drawings on sheet 4 would tend to keep constant potential. In every special case to get constant potential it would be necessary to know the work the machine was to do.

Does Brush's specification disclose the invention of the series-shunt?—I think it does.

Would it be possible in such a specification to give directions which would enable a workman to make every type and variety of machine to produce electricity at a constant potential?—I think it would be quite impossible. That must be calculated outside of what is set forth in the specification.

Is the machine described in Brush's specification a compensating machine?—It is. In this particular machine the current generated by the machine may be passing through an electro-plating bath, and in that bath there may be several objects to be coated with silver. When one is taken out, unless it is compensated for, a greater amount of current will flow through, and that would cause the silver to be deposited more thickly. But in this machine as the current in one wire increases that in the other

decreases, and you have really compensation. Constant potential was a term only introduced in the last few years. It was not in use in 1878. Witness had, on February 4th, 1887, at the Brush company's works, made tests of an early Brush compound-wound machine for electro-plating, and he found that the current varied from 300 ampères, which was a very large current, to nothing, and that the potential remained very constant indeed. There was a variation between the extreme load and no load of 22 per cent. He handed in a table (number 64) giving the detailed results.

Cross-examined by Mr. GRAHAM MURRAY.—So far as constant potential is concerned, and as now required for incandescent lighting, of course you would not dream of accepting a machine with 22 per cent. variation?—No. The usual limit allowed now was 5 per cent. Compensation would be got, but not to the same extent, by a pure shunt machine.

But is it not the fact that from other reasons pure shunt is preferred by many for electro-plating?—In England it is, but in America the compound is preferred. In his examination-in-chief, when using the words Brush system he did confine their meaning to machines series-shunt wound.

As a matter of fact, nearly the whole of the Brush arc lighting was done with machines not series-shunt wound, but series wound?—It was. It was only when the incandescent lamp was introduced that the necessity of series-shunt occurred, but for other purposes it was most important. He could not recall when the first series shunt machine that he knew of was actually in use, but he thought the Navy introduced it in 1882 or 1883. Jablochkoff's candle was a semi-arc light: it was not incandescent. In making the calculation that Varley's machine was a very uneconomical one, he had assumed it was connected up as a series-shunt machine. If he had assumed it as connected with separate excitation, it would have been just as bad.

Nevertheless, taking it at its own date, was Varley's machine such a bad one when Varley invented it?—Well, I should say it should have been chucked on the dust-heap.—(Laughter.)—It is a very poor machine. I think if it had not been a poor machine we should have heard more about it.

Have you calculated at all what was the proportion of waste in, say, Wilde's machine?—No.

If I put this figure to you that Wilde's machine wastes 90 per cent. and has 10 per cent. of efficiency, is that consistent with what you believe to be the fact?—No. Of course I don't express an opinion about the efficiency or non-efficiency of Wilde's machine, because I know nothing about it.

Have you ever devoted your attention to finding out what was the percentage of waste in the early machines, such as Wilde's, Ladd's and Ruhmkorff's?—No, I have not.

Then, as a matter of comparison of the waste of Varley's machine with the machines of its day, you cannot say whether it wasted more or less than them?—I cannot.

Coming to your reading of the specification, you said that taking it as a whole it described various types of machines, and that these all referred to ordinary series machines, until you came to the passage upon page 8, line 38. Now I ask you to show me a single passage, till you do come to that, which has to do with the winding of the field magnets of the machine at all, or infers that the field magnets are to be wound in a particular way? At the top of page 8 it says, "I now proceed to describe the construction of the commutators of a machine having three bobbins of each group. The ends of the insulating wires of the bobbins are connected to metal discs mounted on the axle of the machine, but electrically insulated from it and also from the winding. There may be three discs to each commutator, two of those discs being employed for changing the connections and one for cutting out the bobbins from the electric circuit. Will you tell me what is inconsistent in that from the machine being wound series-shunt?—It can only possibly refer to one subject, whether series or shunt.

Several other questions were put without Mr. Murray reaching his point, and witness ultimately said that he must take the whole description before he could answer the question how he could say that the above words led to the supposition that the machine was to be wound in any particular way.

In answer to Lord TRAYNER witness said he could not recall any particular passage in the specification which referred to the mode in which the field magnets were to be wound, but he inferred it from something else, namely, the whole construction of the specification.

By Mr. MURRAY: He was obliged to take the matter in connection with Varley's previous machines. In specification 1,755, it would be found how the field magnets and the bobbins were to be wound, and the present machine was a mere improvement on that. The passage he had been asked about only referred to commutators, and he should therefore say that the winding of the magnets was to be similar to that in the previous machine. He also found a reference to the method of wrapping on page 2, line 32, which spoke of the dividing of the bobbins into groups. The statement on page 8, line 40, as to winding the soft iron magnets with two wires was, he admitted, quite inconsistent with series winding. The patentee was certainly entitled to wrap his magnets in any of the machines antecedently described in the mode expressed at line 40.

Can there be any reason for winding a magnet with two wires except either to send currents through both of these wires, or to send a current through one and to create induction in the other?—Well, yes. There are at least 200 different ways in which it is possible to work magnets wound with two wires, and at least 50 different purposes to which they can be applied.

That may be perfectly true, but it is not the answer to my question. Do not all those different ways and purposes arrange themselves into two groups, either where current is to be sent through both wires, or where current is to be sent through one wire with the object of exciting induction in the other?—It would be so. Induction was quite out of the question in this case, and therefore the method of winding meant that an electric current, or currents, should pass through two wires which surrounded the field magnets. There was no other system of winding in which that arrangement was required, except series, pure shunt, or series shunt. The part of the specification which stated that the greater portion of the current passed through the circuit of less resistance, maintaining the magnetism of the magnets and producing the electric light, witness, on pressure, admitted excluded the idea of pure shunt. It was also impossible to have separate excitation, assuming that Varley's machine was arranged as described. Double shunt was also excluded.

Are you not then reduced to series shunt?—No.

Lord TRAYNER: What is left? Well, my lord, two wires. We have not yet agreed upon the function of these two wires, and we never shall. It was next elicited from witness, but only by a number of questions, that if Varley's machine, when connected with the Serrin lamp, showed a great increase of magnetism when the lamp was lighted, the machine must be series wound. He did not admit that sparking at the brushes when the lamp circuit was opened indicated that there was another coil round the magnets. Series machines gave sparking at the brushes, due to residual magnetism. Even in modern wrought iron machines this was observable. With the commutator arranged as at present it would not have been possible to have the machine separately excited from a portion of the armature. Witness afterwards was asked a number of questions as to the arrangement of the bobbins.

Re-examined by Mr. JAMESON: Fig. 17 in Varley's specification showed a series winding. It was the ordinary way of showing winding.

ROBERT PERCY SELLON, the next witness, in answer to the DEAN OF FACULTY, said: I am the chief electrician to the Anglo-American Brush Light Corporation in Scotland, and have occupied that position since 1883. The patent in question was purchased by the Brush Company in December, 1880, from a previous company which had purchased it at the end of 1879, who again had acquired it from Brush. The price paid by the original company to Brush was £27,000 for the English and colonial patents. The present company paid £25,000 in 1880 for the English patents. The patent now in question has been twice amended—viz., in 1882 and 1885. I am well acquainted with the history of the Brush Company's business, and of their trade in dynamos. The arc light was almost exclusively in demand, in the early days of the company. There was then no demand for the incandescent light. The series winding system, according to the Brush patent, was first introduced immediately upon the formation of the company at the end of 1879. It has been very largely used both in this country and abroad. A great many hundreds of the Brush series shunt dynamos have been sold in this country and abroad since 1879 for arc lighting and arc lamps. The Brush Company commenced to supply series shunt machines in the year 1880, and since that time they have supplied continuously series shunt winding dynamos for the purpose of electro-plating. They have been found to be exceptionally useful for that purpose. I am speaking from personal knowledge and from what I have ascertained from the business of the company. The series shunt electro-plating machines were received by the Brush Company from Mr. Brush in America between 1880 and 1883. There were seven received between those dates, at any rate. The first one was in September, 1880, and so on, until 1883. These dynamos have been used and applied for electro-plating and electrotype purposes, both in this country and abroad. These machines have been supplied to the *Graphic*, and to firms in Madras and Genoa, and to the Royal Dockyard at Portsmouth. These were all series shunt machines used for electroplating. I myself have tested some of these machines sent over from Mr. Brush, and the question of constant potential came under the tests. The series shunt dynamos, ranging over the period from 1880 to 1883, gave substantially the results that have been indicated in this case. They maintained potential constant within about 15 to 20 per cent. They are substantially similar to the table put into court by Professor Perry. With reference to these machines I examined the proportions of the windings of some of them to see how far they were in conformity with the drawings. I made the observations between 1880 and 1883. The windings upon the drawings correspond to the proportions shown on Brush's drawings. The machine in the *Graphic* office was dated February, 1881. The machine, D 14, of which Mr. Preece spoke was received also in February, 1881. The two machines which Professor Thompson examined in our works were manufactured by Brush under the Brush patent in question, one of them in February, 1881, and the other is later in the same year. They had been worked from the time they were received until examined by Mr. Thompson. Up till the summer of 1882 there were no series-shunt machines in the market for any purpose whatever with the exception of the dynamos supplied by the Brush company under their patent. There was no attempt to infringe the patent of which we were aware up to 1883, and no attack made made on the validity of the patent. During the years 1881–82–83 the incandescent lamp became so perfected as to create a demand for series shunt dynamos. The first really series shunt dynamos made for incandescent were made by Mr. Brush in July, 1882. In the summer of 1883 the Brush Company in England

commenced to supply series shunt machines specially for incandescent light, and since that date they have supplied many hundreds of these machines. Our company first discovered that their patent was being seriously infringed in 1884 or 1885. Since they saw that the infringement was becoming a serious matter, they asserted their claims and insisted upon licences being taken. Messrs. Siemens and various other large manufacturers of compound dynamos accepted licences. There were 22 of the leading manufacturers in this country who accepted licenses. The only persons who contested our rights were Messrs. Crompton and several minor firms, an action was brought against Crompton in 1886, but Messrs. Crompton, at the end of 1887, accepted judgment against them and the case never came to hearing. They paid £2,000 costs and accepted licenses which we gave them at one-fourth less than the usual terms in consideration of the fact that they assigned to us a subsequent patent of the combined winding. The only other action was against the Orion Company, and in it judgment was given in favour of our company by Justice Chitty.

Does Brush's commutator, in your opinion, at all go beyond what is indicated in the provisional specification?—I think the claims are merely carrying out any details foreshadowed in the provisional specification. I have examined the Wilde commutator and the Varley commutator, and I have been in court and heard the views expressed by the defendant's witnesses as to these. I concur in the distinctions they point out as between these commutators and the Brush commutator.

Cross-examined by Mr. MURRAY: I do not know that the earliest constant potential series-shunt machines for electric lighting were supplied by Mr. Brush upon the order of Mr. Swinburne.

You do not know that Mr. Swinburne, in ordering them, communicated to Mr. Brush the way in which he could secure constant potential?—I only know that Mr. Swinburne says so and that Mr. Brush says no.

I have got in my hand a statement of the stock your company had in May, 1883, which discloses that you do not seem to have had a single series-shunt machine in stock in Scotland?—This statement shows that there were no series-shunt machines in stock.

As to the machines used for electro-plating can you say that any of those electro-plates were made of anything else than copper or silver?—Not to my knowledge.

Is it the fact that nickel has a greater tendency to reverse the current than either copper or silver?—It has a greater tendency.

£27,000, you said, was the price paid by the original company to Brush, do you say that Brush got the £27,000?—No, I cannot say; I do not know what Brush did get.

You do not know that he only got about £6,000?—No, I do not know.

Mr. MURRAY then intimated that this practically closed the evidence to be taken before his Lordship, except that he considered it necessary to recall the two witnesses from Siebe and Gorman's, in order to show there was no key upon the circuit of the kind suggested by Professor Perry that morning. His information was that there was no such key.

Lord TRAYNER granted leave to recall the two witnesses, and it was arranged that they should be examined about the middle or end of January, by which time the evidence to be taken on commission in America will have arrived in this country.

(The case was then adjourned until January.)

LEGAL.

Watt v. The Maxim-Weston Electric Company—The Maxim-Weston Electric Company v. Watt.—(Before Mr. JUSTICE NORTH.)—This was a motion on behalf of Mr. Watt, late the managing director of the Maxim-Weston Electric Company, to commit Mr. John Marks to prison for contempt of court in having made certain statements in a speech delivered at a reconstruction meeting of the company held on the 3rd inst. Mr. Marks was chairman of the meeting. The ground on which the motion was made was that the statements related to the matters in dispute in the legal proceedings pending between Mr. Watt and the company, and tended to prejudice a fair trial. It appeared that a shorthand writer was employed by the directors of the company at an expense of five guineas to take down what happened at the meeting, and the proceedings were reported, and the obnoxious statements appeared in the report in the *Financial News* and the *Electrician*, and as many as 1,800 copies of the former paper were purchased for distribution by the directors of the company, for which £7 10s. was paid. The words complained of as reported in the *Financial News* were as follows:—"He said deliberately that the last balance sheet Mr. Watt issued to the shareholders was absolutely false. It showed a false profit, on which Mr. Watt had taken 5 per cent. commission. Not only that, but there were sales entered in the books as *bona fide*, and which they found were bogus sales, large profits arising from these being shown on the books, but on which in reality the company made a serious loss. Mr. Watt had taken 5 per cent. commission on these. It was Mr. Watt's management, or rather mismanagement, which had brought them to their present position." Mr. Marks in his evidence asserted that the report was not absolutely correct, inasmuch as he had not charged Mr. Watt with taking, but only with claiming the 5 per cent. commission; but in this his Lordship considered Mr. Watt mistaken. At the beginning of his speech he had himself explained that he intended to refrain from going into the matters in dispute because the legal proceedings were pending, and it was in answer to questions, he said, that he was drawn into making the statements complained of, and he claimed privilege.

Mr. Napier Higgins, Q.C., and Mr. George F. Hart appeared for Mr. Watt in support of the motion; Mr. Cozens-Hardy, Q.C., and Mr. Gazdar, for Mr. Marks, opposed.

Mr. JUSTICE NORTH considered it was not a case in which the respondent should be sent to prison, but he did consider it a case in which he had transgressed the rule of the Court which required parties to abstain from publishing matter tending to obstruct the course of justice. He said that, though Mr. Marks had not himself ordered the employment of the reporter for the purpose of publishing the proceedings at the meeting, he was one of the directors who had acquiesced and was responsible. With respect to the defence of privilege, if it were the case that Mr. Marks would have been justified in making the remarks to his own shareholders in response to enquiries, that did not apply to the publication to the world in the newspapers, and it was not like a case where the remarks had got into the newspapers without authority. He therefore ordered the respondent to pay the costs of the motion.

CORRESPONDENCE.

Alkaline Accumulator.

On more than one occasion lately I have noticed remarks made upon the new alkaline secondary battery now so largely used by the French Government, and my name is brought forward in such a manner as to lead one to suppose that it was, at least, by my consent that these quotations appeared.

Please allow me to state that the remarks in question were made without either my knowledge or authority, and although, perhaps, correct upon most points, they are incorrect in others.

As little appears yet to be known in England of this invention, I hope shortly to send you a full description. The only one I have yet seen in English papers was quoted from Reynier's book, and I think most people would agree with me that no one is likely to be *more* prejudiced against a new secondary battery—especially one without either lead or acid—than the electrician to MM. Philippart.

P. Bedford Elwell.

December 25th, 1888.

The Barnet Lighting.

We observe with much regret that an extract from your article of the 14th inst. is printed in the *Barnet Press*. Had we known of this article previously, we should have written you to advise you that you were in error in stating that we blamed a discharged workman for the temporary breakdown on the 8th inst.; no such thing. It is quite wrong to ascribe any such meanness to us, and it is a pure fiction of the local penny-a-liner from whom this report has evidently emanated.

We do not agree with your opinions of the Barnet lighting, and fail to see why you take so extreme an exception to that enterprise. We consider the incandescence light is suitable for street lighting, and many engineers who have visited Barnet agree with us. We think that your criticism is not adapted to advance the interests of electric lighting.

Henry F. Joel & Co.

December 27th, 1888.

[Messrs. Henry F. Joel & Co. are too hasty; they do not look before they leap. That little episode of the discharged workman appeared in the London morning papers, and if our correspondents, by the local penny-a-liner, allude to anyone connected with the *Barnet Press*, we can only say that that paper, in its issue following the Barnet catastrophe, contained no notice of the mishap. Messrs. Joel & Co.'s opinion of our criticism is only natural, but better check this kind of thing in its infancy than let other towns be subjected to the same fate as Barnet.—EDS. ELEC. REV.]

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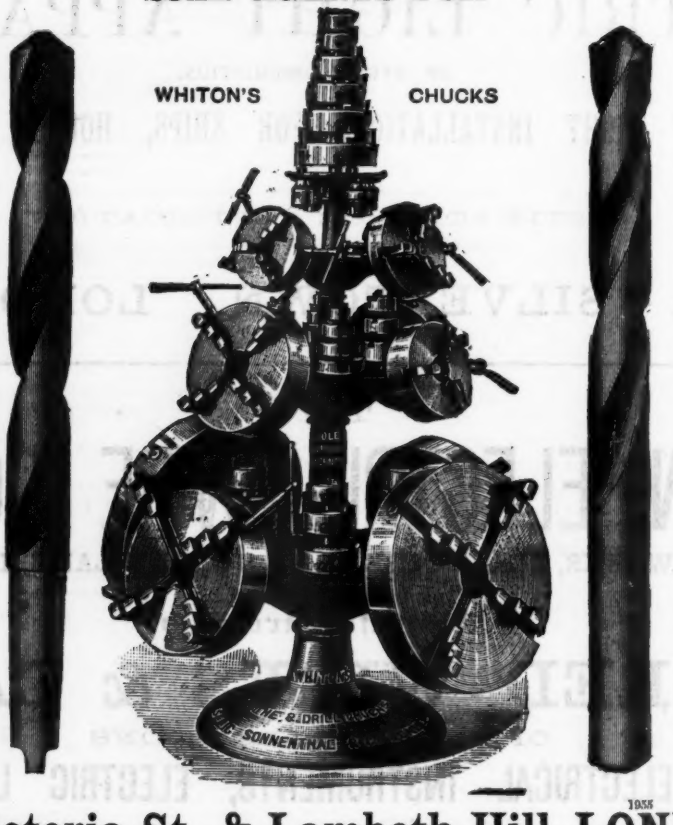

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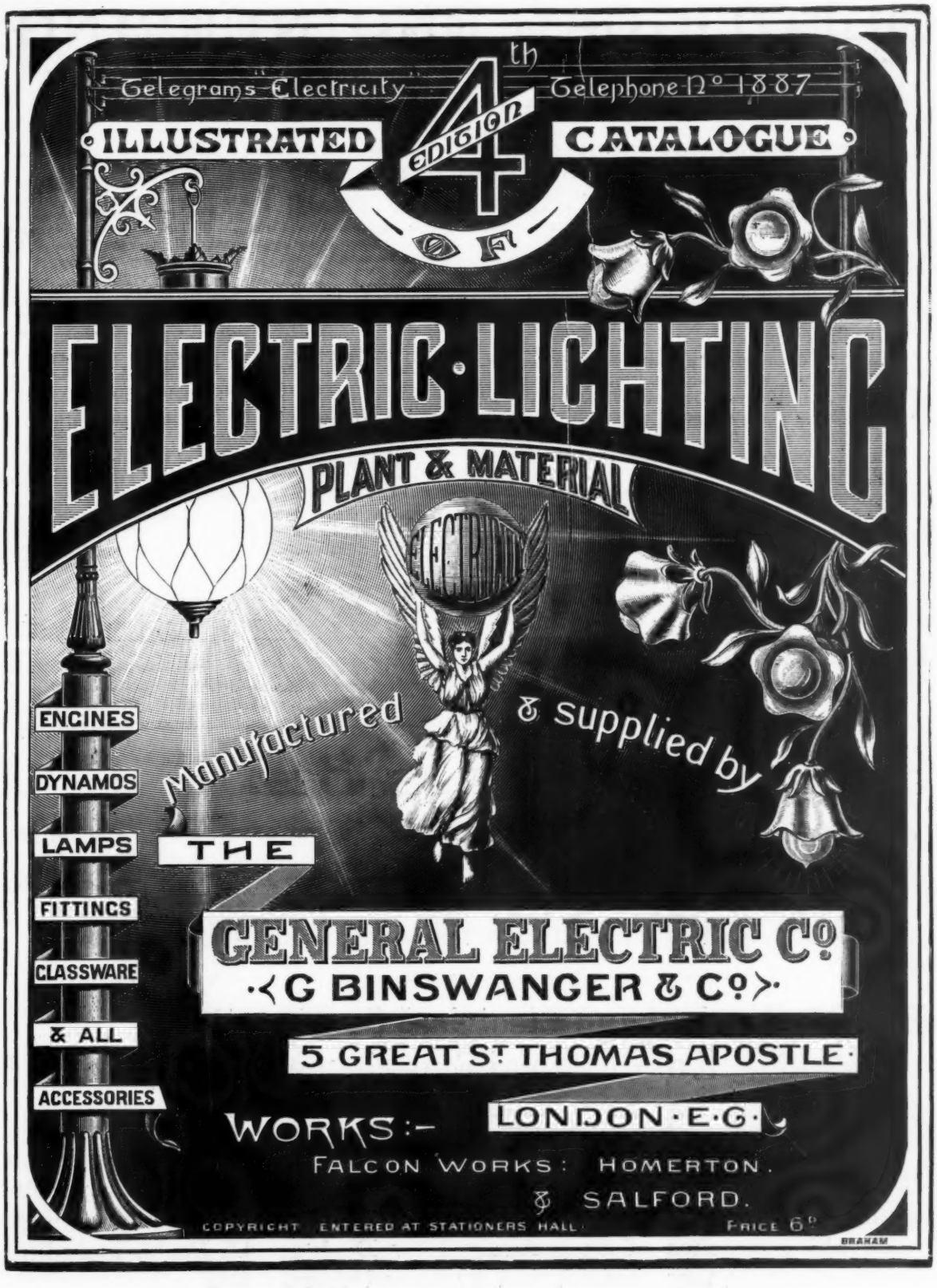

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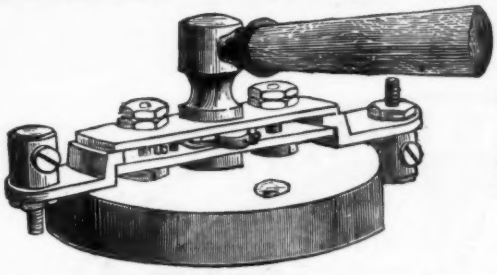

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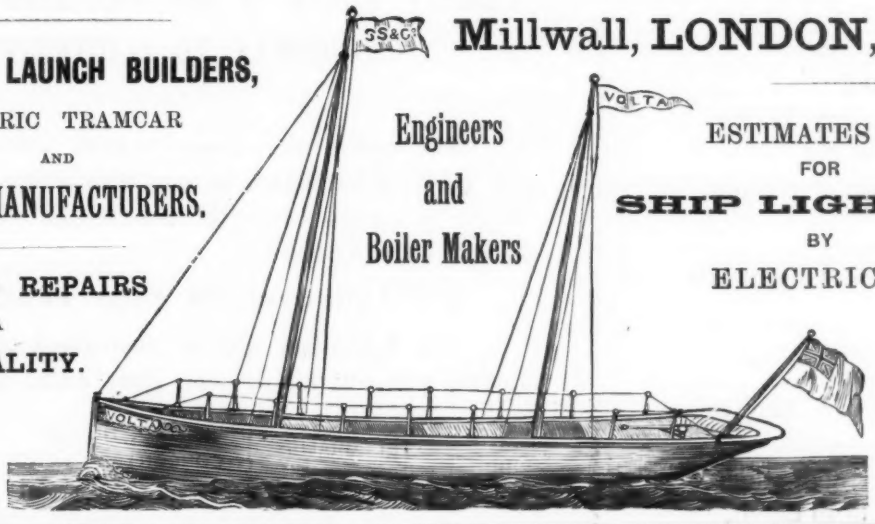

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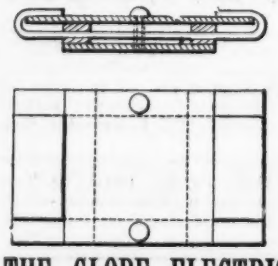

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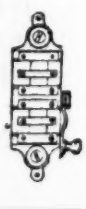

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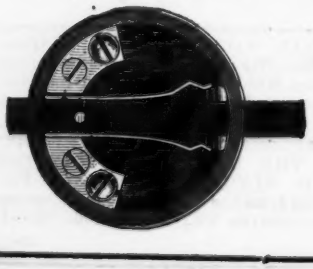

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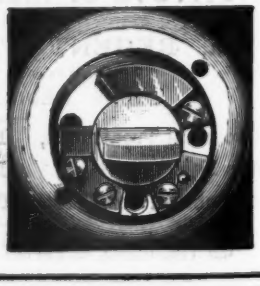

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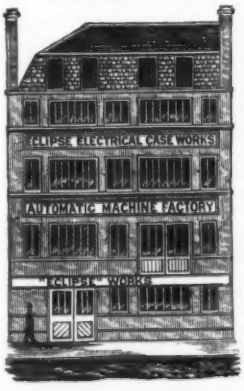

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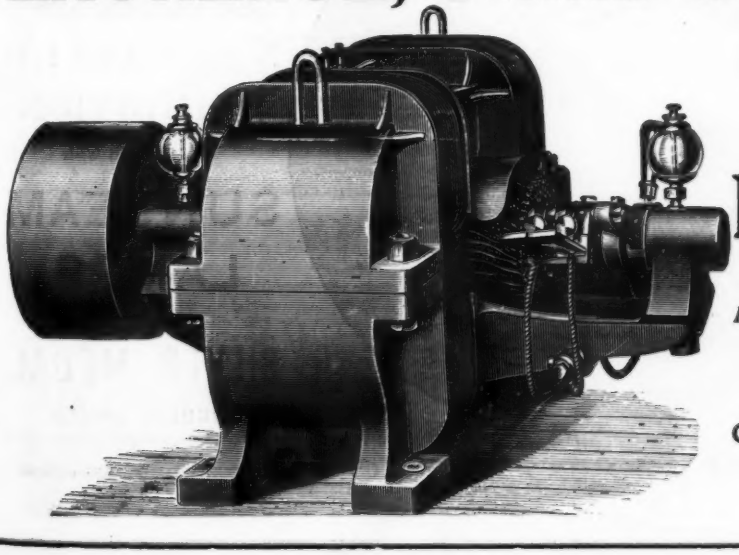

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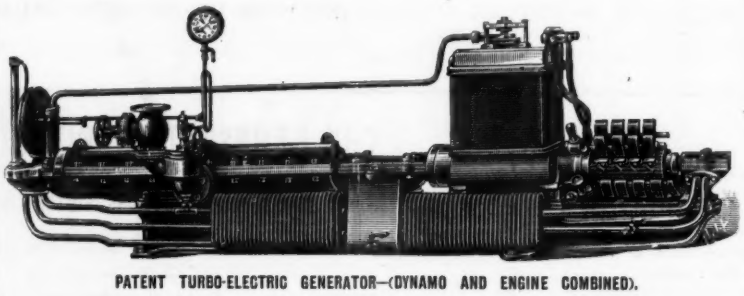

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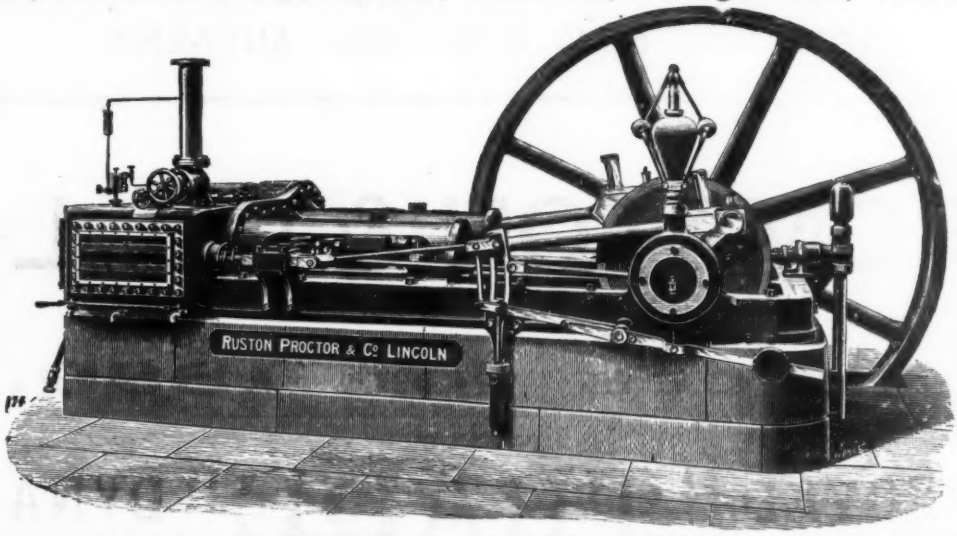

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VOL. XXIII. NOVEMBER 16, 1888. No. 573.

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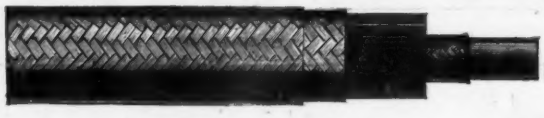

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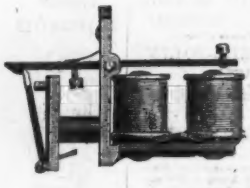

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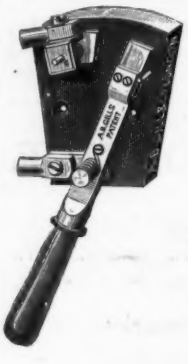

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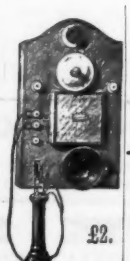

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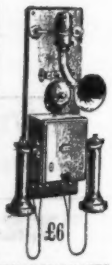

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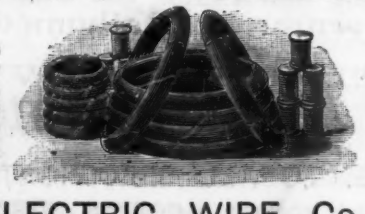

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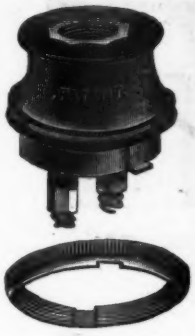

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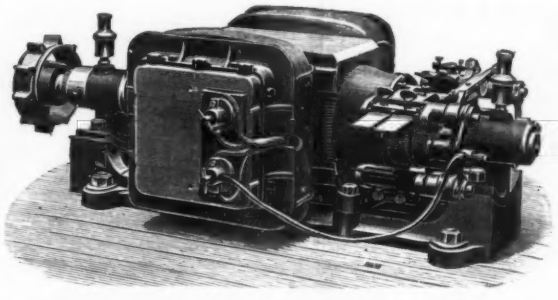

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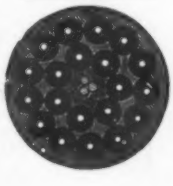

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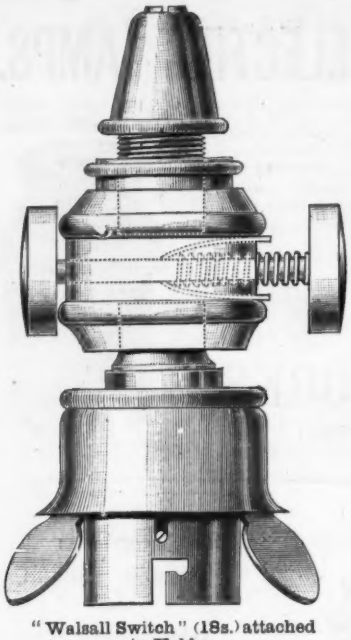

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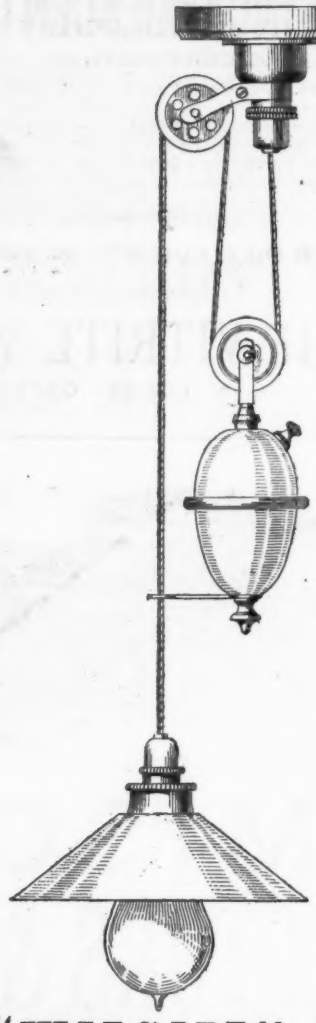

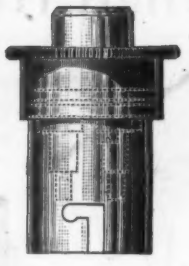

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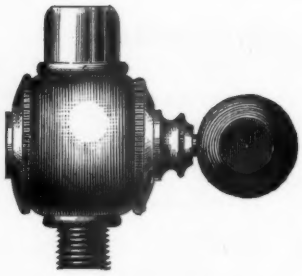

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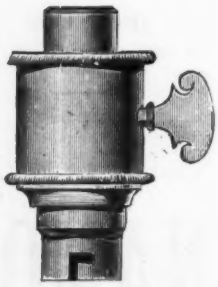

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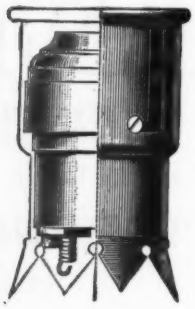

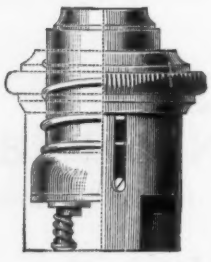

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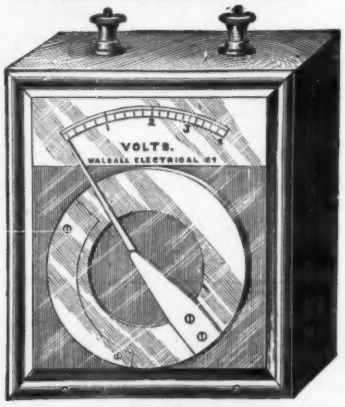

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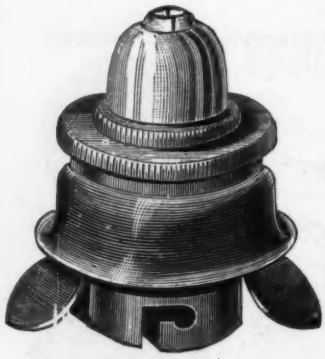

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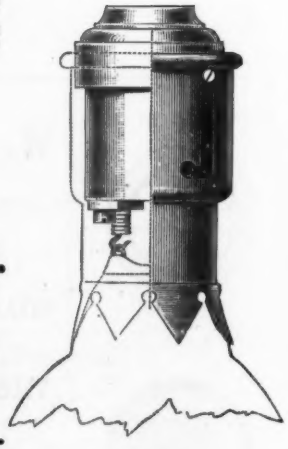

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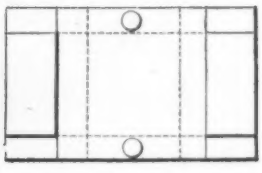

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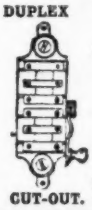

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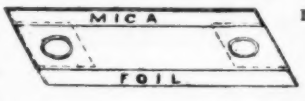

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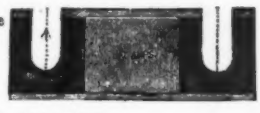

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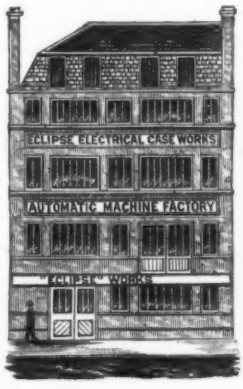

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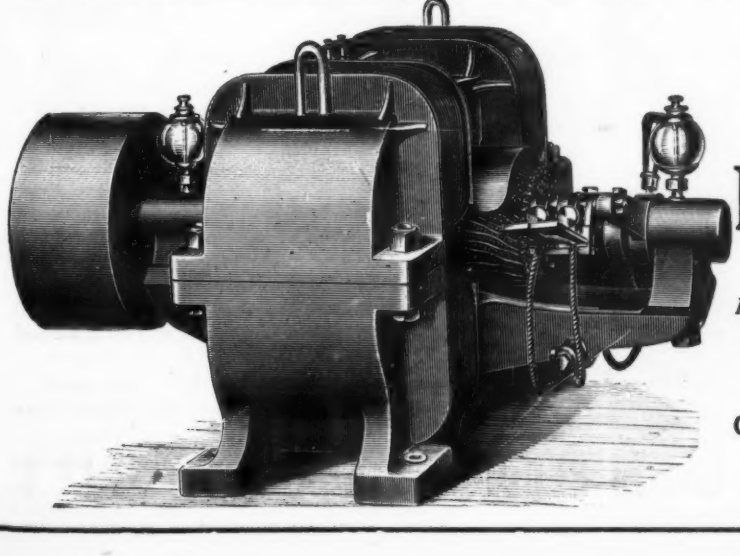

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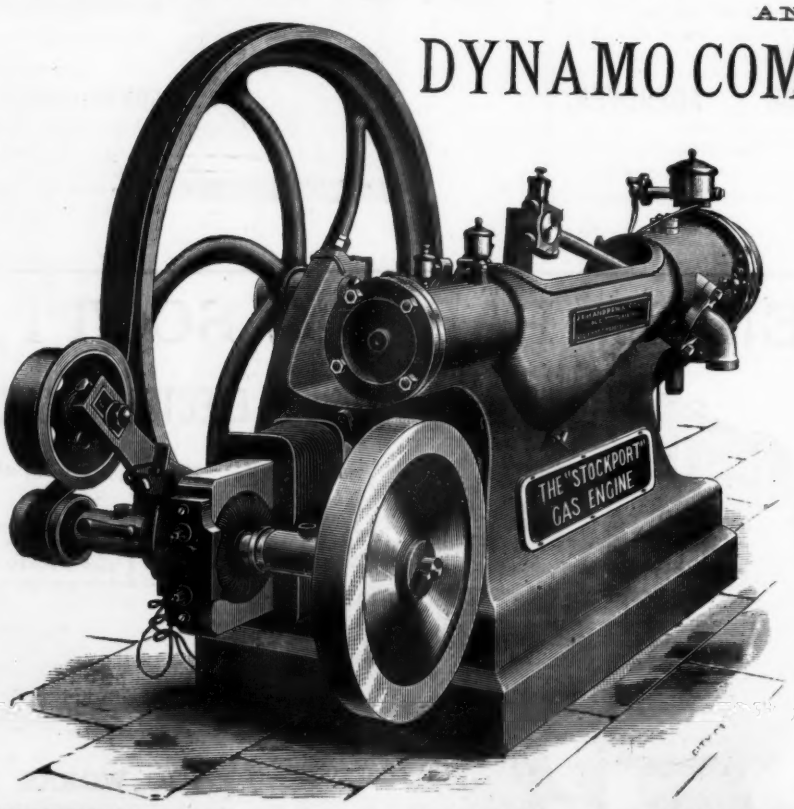

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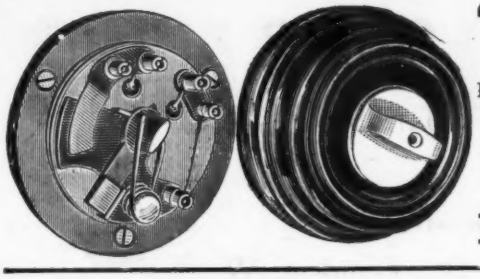

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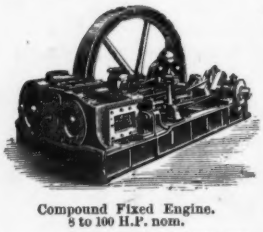

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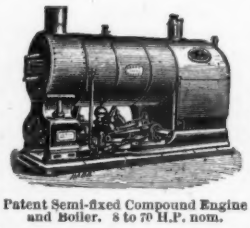

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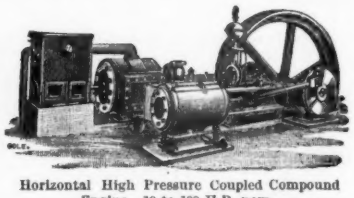

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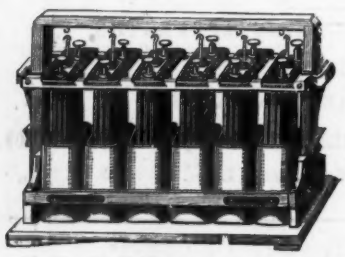

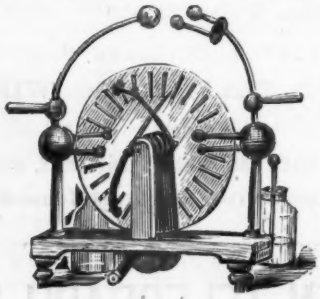

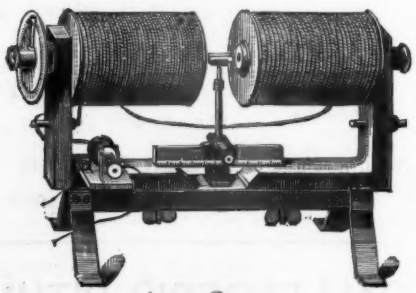

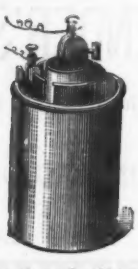

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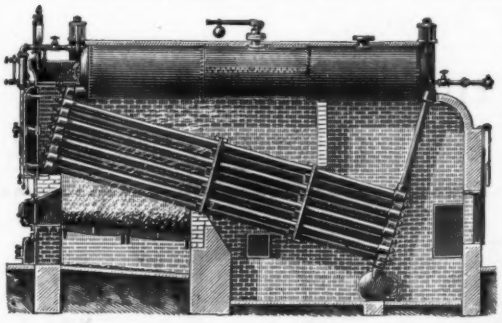

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ARMINGTON-SIMS PATENT ENGINE,

SPECIALLY ADAPTED FOR

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AND FOR ANY WORK WHERE UNIFORMITY OF SPEED IS DESIRABLE.

GOLD MEDALS:
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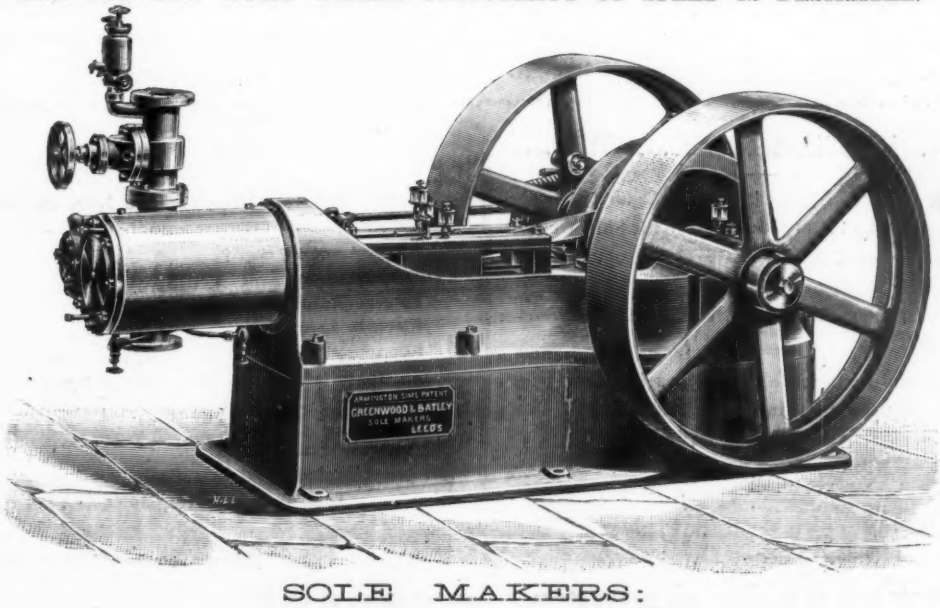

GOLD MEDAL
Awarded at the International Inventions Exhibition, South Kensington, 1885.

SOLE MAKERS:

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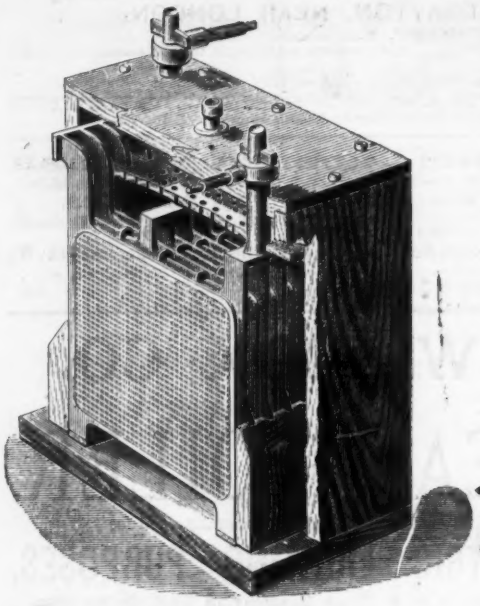

L Type (15 Plate) Ship Lighting Cell.

Storage Batteries.

New 1888 Type.

Most perfect ever produced.

Mechanically the simplest.

Electrically a great advance.

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ELECTRICAL POWER STORAGE.

New Publications.

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E.P.S. ACCUMULATORS, STANDARD TYPES.

L Type (Glass Cell), Great Storage Capacity.
L Type (Teak Cell), specially made for Ship Work.
T Type for rapid discharge Traction Propulsion.
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V Compact Portable Sets for Vehicle Lighting.

Special Cells made to specification for—
Central Station Lighting,
Telegraph and Telephone Purposes,
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Regulating Switchboard, 60 to 1,000 amperes.
Automatic Apparatus.
Heavy Current Switches.
Measuring Apparatus.
Electro-Motors.
Electric Launches.
Electric Tramcars, and every requisite for Installations on the Storage System.

Contractors for—
Central Station Lighting,
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ELECTRICAL POWER STORAGE COMPANY, LIMITED,

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Telegrams: "Storage, London." Telephone No. 338.

INDIA-RUBBER. EBONITE.

DAVID MOSELEY & SONS,

Chapel Field Works, ARDWICK, MANCHESTER.

WAREHOUSES:

2, 4 & 6, New Brown Street, MANCHESTER.
14, Aldermanbury Avenue, LONDON.
57, Miller Street, GLASGOW.
20, Rue des Marais, PARIS.
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Sheets, Rods, or Tubes. Separators, Influence Machines for High-Tension Currents. Cylinders and Plates.

For ELECTRICAL Purposes.

VULCANITE & EBONITE

Sheets, Tubes, Pumps, Valves, Balls, Taps, Elbows, Flanges, &c.

For CHEMICAL Purposes.

INDIA-RUBBER

Sheet, Washers, Valves, Cord, Tubing. Ball Valves, Buffers, Door Mats. Packing of all descriptions. Delivery and Suction Hose.

For ENGINEERING and MECHANICAL Purposes.

SOLE MANUFACTURERS OF THE "SIMPLEX" COTTON BELTING AND THE "ANCHOR" FIRE BRIGADE HOSE.

Waterproof Garments, Fishing and Sporting Articles. Surgical and Chemical Articles. Bicycle and Perambulator Tyres, and all descriptions of India-Rubber Goods.

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MARSHALL, SONS & Co.. LTD.,

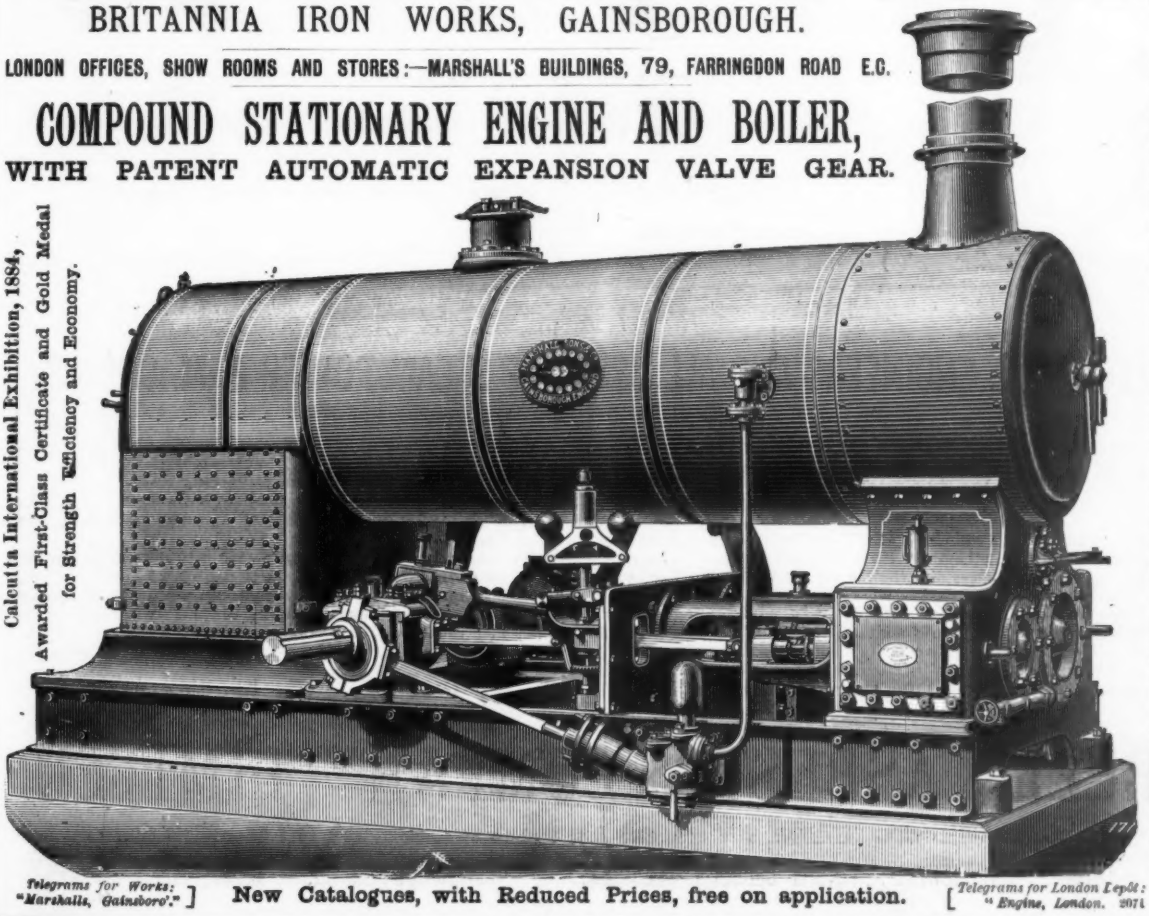
BRITANNIA IRON WORKS, GAINSBOROUGH.

LONDON OFFICES, SHOW ROOMS AND STORES:—MARSHALL'S BUILDINGS, 79, FARRINGDON ROAD E.C.

COMPOUND STATIONARY ENGINE AND BOILER,

WITH PATENT AUTOMATIC EXPANSION VALVE GEAR.

Calcutta International Exhibition, 1884, Awarded First-Class Certificate and Gold Medal for Strength Efficiency and Economy.

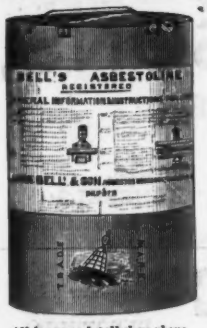


Gold Medal, Highest Award, Liverpool Exhibition, 1886; Gold Medal, Highest Award, Edinburgh Exhibition, 1886.

Telegrams for Works: "Marshalls, Gainsboro'."] New Catalogues, with Reduced Prices, free on application. [Telegrams for London Depôt: "Engine, London. 2071

BELL'S ASBESTOLINE.

REGISTERED.



All kegs are labelled as above.

ADVANTAGES OF ASBESTOLINE.

ASBESTOLINE is the most efficient Lubricant for all bearings.
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ASBESTOLINE is the Cleanest Lubricant.
ASBESTOLINE is favoured by Insurance Companies.
ASBESTOLINE is the most Inodorous Lubricant.
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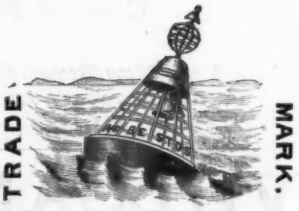

BELL'S ASBESTOS.

CONSISTENCY OF ASBESTOLINE.

ASBESTOLINE, to meet all circumstances, is made in four degrees of consistency, A, B, C, and CC.

ASBESTOLINE, A, is specially adapted to ordinary Land Engines and Machinery, in and out-door, in this country.

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Supplied in Kegs, 28, 56, or 112 lbs. Price 2s. 3d. per lb. Kegs Free.

SPECIAL TERMS FOR LARGE QUANTITIES.

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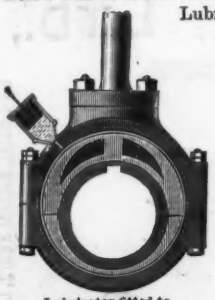
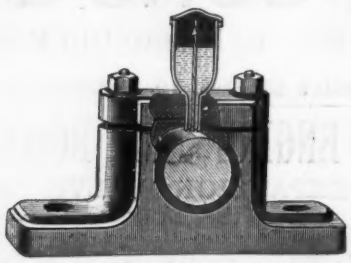
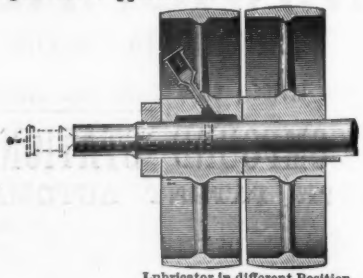


Lubricator fitted to Excentric of Vertical Engine.



Showing Section of Lubricator fitted to ordinary Bearing.



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I found that Abestoline **ignites only with the greatest difficulty** when brought into contact with flame; that wood and other combustible material soaked in Asbestoline burns, if anything, with greater difficulty than by itself, that its **flashing point** is so high that it **lies beyond the range of Mercurial Thermometers,** and that consequently no friction obtainable in the ordinary run of machinery is capable of developing inflammable vapours from it.

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From the physical nature of Asbestoline its use is of necessity perfectly clean and free from waste.

(Signed) OTTO HEHNER, *Public Analyst.*

BELL'S ASBESTOS COMPANY, LIMITED,

ILLUSTRATED PRICED CATALOGUE, WITH NUMEROUS TESTIMONIALS BY LEADING FIRMS, FREE ON APPLICATION. 2222

Depots:—MANCHESTER: Victoria Buildings, Deansgate. LIVERPOOL: 2, Strand Street, James Street.

BELL'S ASBESTOS

NON-CONDUCTING COMPOSITION

For Covering Boilers and Steam Pipes.

WILL REDUCE LOSS BY RADIATION TO A MINIMUM AND SAVE 40 PER CENT. OF FUEL.

It is essential in a covering that it shall not only be a non-conductor, but a substance free from whatever can injure metal, and of a nature which will enable it to adhere well for years. To do this it must be sufficiently elastic to prevent cracking and leaving, by expansion and contraction, the heated surfaces to which it is applied. This Composition is daily applied to Tanks **with Round or Flat Bottoms,** and its adhesive properties enable it to keep to the surfaces without bands or any device necessary for holding on other compositions. Our Covering never fails to **Save its Cost in a few months, lasts for years,** after which it can be taken off and applied again with a little fresh. In all respects it is so superior as to be infinitely cheaper than Compositions sold at one-fourth the price. We would point out that this being supplied **dry in bag,** will cover **six times** more surface than other materials which are sent out wet in cask. This shows the apparent low prices of other Compositions to be a sham.

For Export about one-third cost of freight is saved as compared with Compositions sent out in a wet state. In competition its never failing efficiency has repeatedly proved it to be the **cheapest material** in the market for prevention of loss by radiation.

Price 25s. per Cwt. Second Quality, 15s. per Cwt., is superior to the best sold by other firms.

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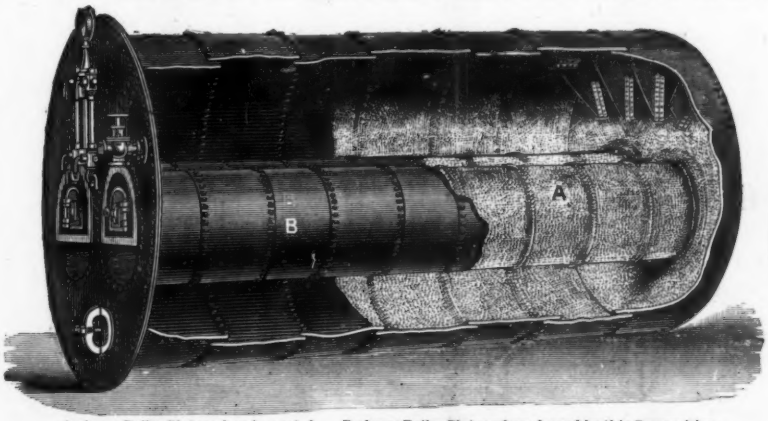
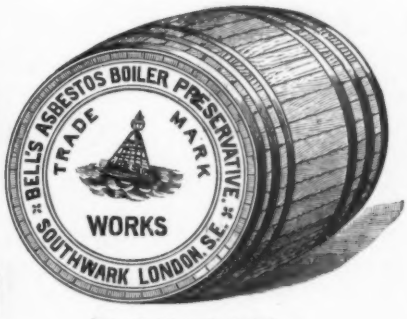
Will remove incrustation from Steam Boilers of all kinds without chipping.



A shows Boiler Plates when incrusted. B shows Boiler Plates when cleaned by this Composition.



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Price 4s. per Gallon. Second Quality, 2s. 6d. per Gallon—guaranteed superior to the best sold by other firms.

QUANTITY REQUIRED.—Quarter-pint weekly per H.P. indicated; where the water is very bad rather more, or one pint for every 700 gallons of water evaporated.

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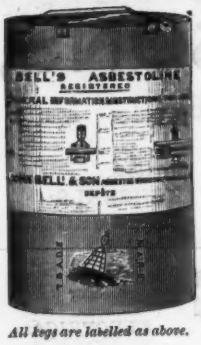

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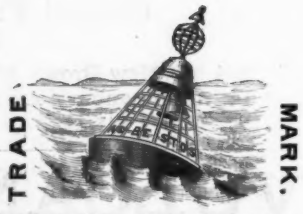

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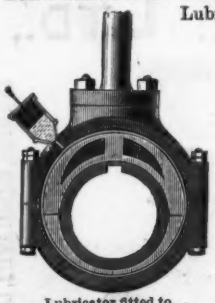

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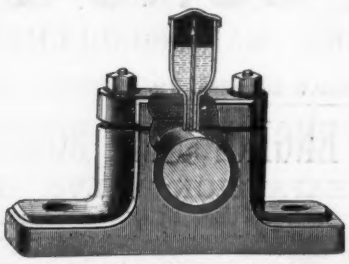

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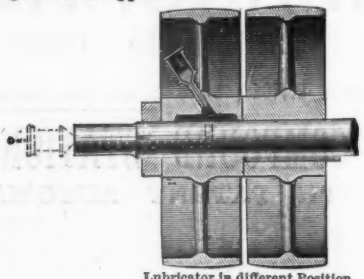

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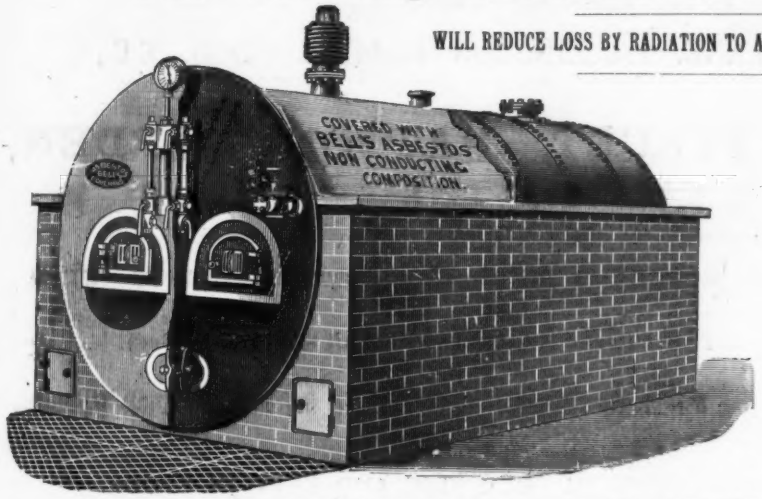

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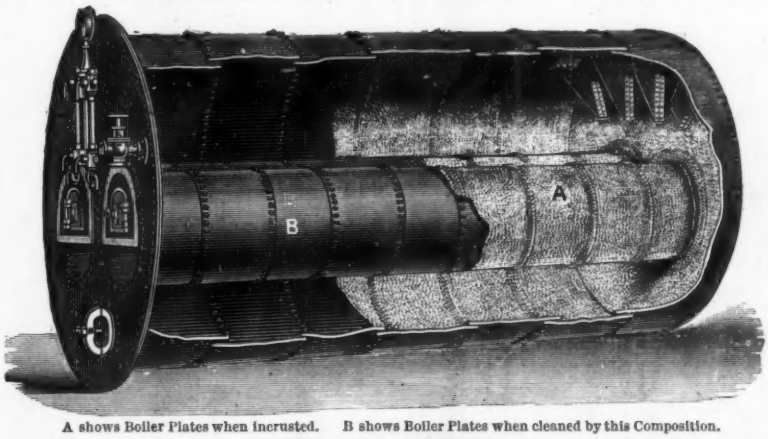
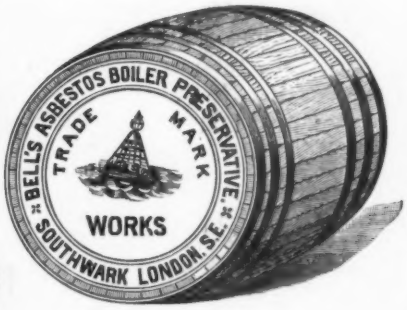


A shows Boiler Plates when incrusted. B shows Boiler Plates when cleaned by this Composition.



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DAVIS & TIMMINS,

LIMITED.

Screw Manufacturers & Metal Merchants,

HAVE REMOVED FROM

BOWLING GREEN LANE, FARRINGDON ROAD, LONDON, E.C.,

TO

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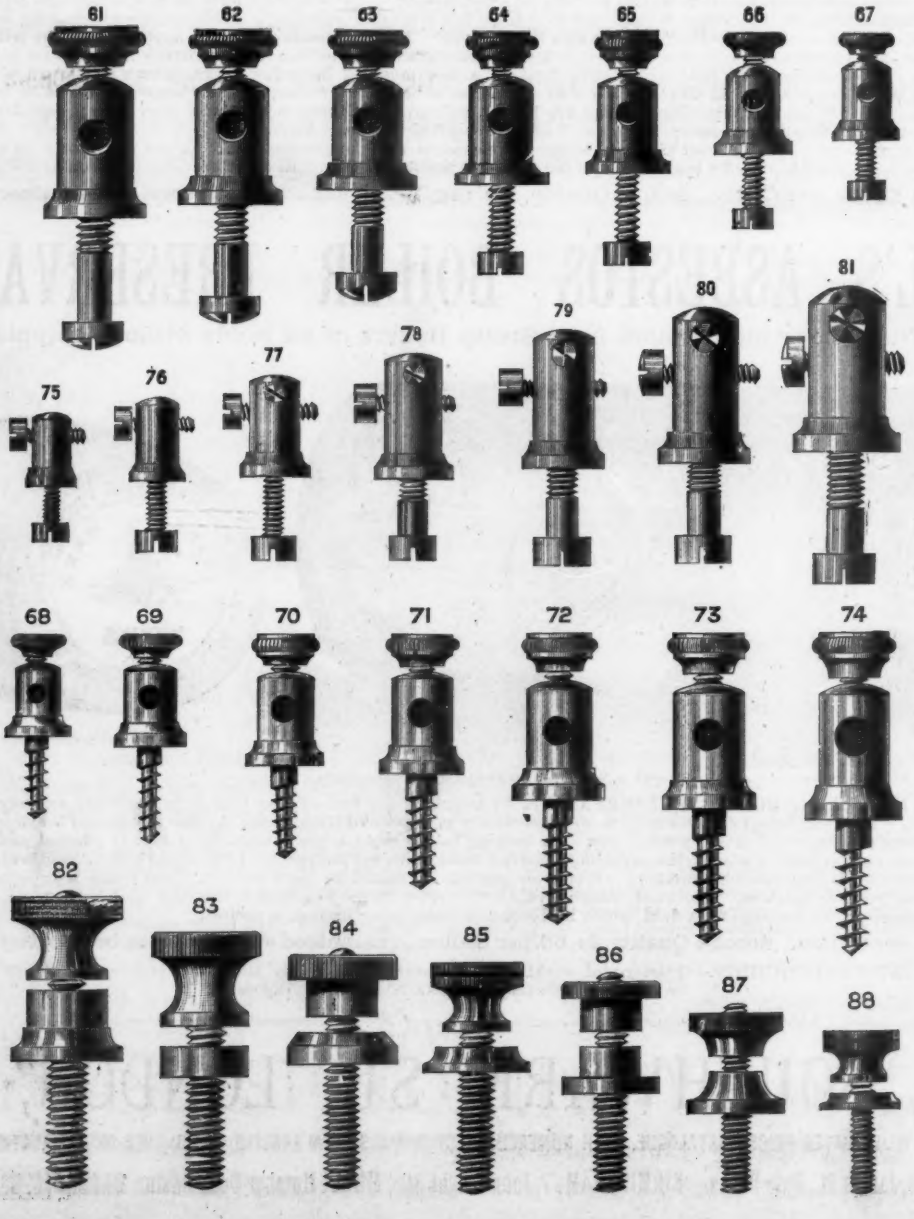

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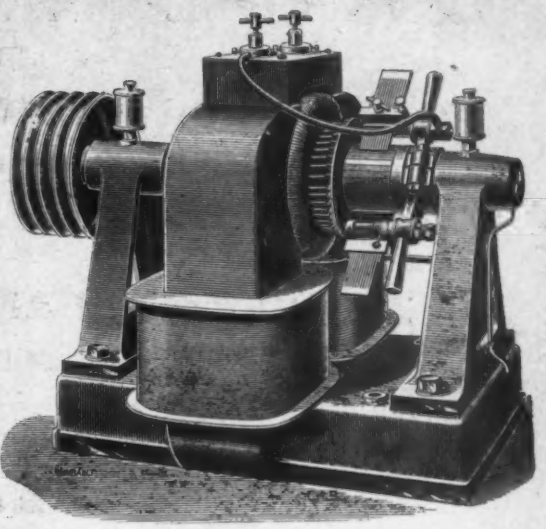

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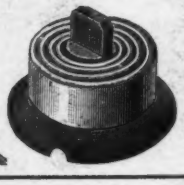

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